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PHILADELPHIA MANUAL TRAINING SCHOOL.

NOTES ON BUILDING CONSTRUCTION

AND

ARCHITECTURE.

BY WILLIAM S. ALDRICH, M. E.

DIVISION I.

Building Construction.

Object.—To familiarize the pupil with the materials, processes and principles of Building Construction; the typical forms of structures; sanitary considerations and conditions; and the elements of planning and design.

How Accomplished.—1. By short talks and illustrated lectures; study of notes, drawings, charts, photographs; reference to standard books on the subject.

2. Study of existing buildings and structures, and the typical forms found therein, with special reference to the requirements and the application of the principles of construction.

3. Examination of buildings in course of erection for methods and processes.

4. Architectural sketches, drawings and designs; detail working drawings of typical forms seen in buildings and structures; figured sketches of building selected by pupil for a set of finished architectural drawings,—details, foundation and floor plans, elevations, vertical section, and perspective view.

5. Pupils make sketches to accompany and illustrate these notes.

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Reference Books.

In connection with the study of existing buildings and modern methods of construction, much valuable information respecting the underlying principles will be found in the following books of reference:

Notes on Building Construction.—Col. Smith.
Notes on Building Construction.—Burns.
Building Construction and Superintendence.—Clarke.
Building Construction.—Seddon.
Rudiments of Art of Building.—Dobson.
Carpentry.—Tredgold; Nicholson; Bell; Hodgson.
Rudiments of Architecture.—Gwilt.
Rudiments of Architecture and Building.—Bullock.
Technology of Building.—Chateau.
Technical Manuals.—Cassell & Co.
Architect and Builders Pocket Book.—Kidder.
Building Materials.—Shaw.
Proportions.—Atwood.
Hints to Young Architects.—Wightwick.
Specifications and Contracts.—Haupt.
Architectural Drawing.—Worthon; Tuthill.
Architectural Perspective.—Ware; Wright.
Topographical Drawing and Sketching.—Reed.

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PART I.

Planning and Designing.

The designing and building of a structure form three distinct operations, as follows:

1. The conception of the project or plan.
2. Putting this on paper, so that it can be understood.
3. Its execution.

The first requires a perfect acquaintance with the locality where the structure is to be placed; the ends or objects to be attained by it, whether erected merely for utility, or to combine with the useful and ornamental; convenience of arrangement, interior as well as exterior; the kind and quality of materials that can be supplied at that point for its construction. Combine with the thorough examination of the site and its surroundings, tests of the character of the soil for foundation walls, and tests of the building materials found in the locality. Freehand sketches of proposed alterations and outline of buildings, with perspective view of proposed building, will be found useful.

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The second requires finished and accurate drawings to scale; models accompanied by descriptive memoirs; estimates of cost, based upon cost of materials, price of labor, and time required to finish the work; written specifications and contract.

The third may be divided into (a) field-work, or laying out the work; (b) the putting together of the materials into parts; (c) the combining of these parts in the structure; (d) sanitary considerations; (e) the addition and working out of the ornamental features; (f) the application of protective appliances and materials; (g) interior decorations; (h) laying out the surrounding grounds so as best to conduce to the harmony of the whole.

These operations call for a knowledge of surveying, levelling and other work incident to laying out; a knowledge of the physical properties of the materials used; the art of forming them into the shapes required; how they should be joined together to satisfy best the conditions that are to be imposed upon the structure; the influence of climate and soil; heating, ventilation, drainage and other sanitary measures; a knowledge also of the historical development of architecture and ornament; the principles of decorative art and design; and landscape gardening.

LOCATION OF SITE.

This is usually determined by the main considerations of:

I. Utility.

1. Suitableness and fitness for the purpose in hand.
2. Market value of property.
3. Probable rise in value.
4. Healthfulness of locality.
5. Accessibility.
6. Availability and price of labor.
7. Materials found on the spot.
8. Drainage.
9. Water supply.
10. Value of soil for cultivation.
11. Value of natural products.
12. Fuel supply.
13. General considerations of economy, comfort and convenience.

II. Beauty.

1. Natural surroundings.
2. Their adaptability for ornament.
3. Trees and wooded land.
4. Plains and rolling country.
5. Stone and earthwork.
6. Possibility of landscape gardening.
7. Adjacent and surrounding buildings.
8. Elevation of site.
9. Æsthetic value of outlook.
10. Walks, drives, etc.
11. Artificial surroundings.
12. General considerations of the fitness of things from an æsthetic point of view.

I. PLANNING AND DESIGNING.

This part of the work consists of:—

1. **Block Plans.**—Showing general outlines, grouping (if more than one building), character of surroundings and surface. 2. Excavation and foundation plans, basement and floor plans, showing interior arrangements, &c.

2. **Perspective Views.**—Elevations, front, rear and side, and such others as are called for by the peculiarities of the building in hand.

3. **Sections.** — Longitudinal and transverse, showing the interior arrangements of floors, constructive features, &c.

4. **Detail** drawing, showing special features of construction and minor peculiarities, arrangement of stairways, &c., sections of moulding and general woodwork finish, and details on a large scale of all special stone, brick and ironwork, this also includes all ornamental features. Detail drawing should always be on as large a scale as possible. Elevation plans, &c., are usually made on a scale of one-eighth, one-quarter, three-eighths or one-half inch to the foot.

II. BUILDING MATERIAL.

Under this division are included all the materials that enter into the construction, and may be divided into: 1. Constructive materials, as stone, wood, brick, iron, etc. 2. Uniting materials, used to bind the parts together, as cements, mortar, etc. 3. Protective and decorative materials, as paints, tiles, paper, etc.

WOOD.

Abundance and cheapness, ease of procuring and working combined with strength, lightness and durability, recommend it for many classes of construction.

Wood in the tree is standing timber, after felling and cutting into shape for building it is known as rough timber or logs, if from the trunk of the tree it is usually called round, squared, hewn or sawed timber according to the manner in which it has been worked and the use to which it is to be put, the smaller timbers sawn from logs are known as joists, planks, scantlings, boards, strips, etc., according to dimensions. The trees used for building lumber are exogenous, i. e., those that increase in size by the formation of new layers on the outer surface.

Varieties.—For use in construction timber, trees are divided into two general classes.

1. **Soft Wood Trees.**—Which include all coniferous trees like the pines and a few varieties of the leaf-wood trees. They contain turpentine and are distinguished by straightness of fibre and regularity of the form of the tree; timber from them is easily sawed or split along the grain or broken across the grain. Examples: Yellow pine, (or spruce pine), Southern pine, White or Northern pine, and Norway pine; fir, common spruce and Oregon; hemlock, cedar, juniper or white cedar, poplar and cypress.

2. **Hard Wood Trees.**—Which include almost all of the timber trees that are non-coniferous but are argillaceous or leaf bearing. They contain no turpentine and as a class are tough and strong. Among this class are the oaks,—white, live, red, and post; the chestnut, ash, hickory, maple and walnut.

Preparation.—Trees should not be felled while the sap is in circulation, the best and most usual time for cutting is the winter season. When felled the tree should be stripped of its bark and raised from the ground, and in a short time the sap-wood cut off and the timber reduced to dimension stuff.

Appearances of Good Timber.—Among trees of the same species, that one which has grown the slowest as shown by the narrowness of its annual rings will in general be the strongest and most durable. The grain should be hard and compact. Other conditions being the same, the strength and durability of timber increase with the weight and darkness of color. Timber of good quality should be free from knots, defects and all blemishes, and have a straight grain. Examine a cross-section of the log for defects of growth, age or decay.

Seasoning.—Either natural or artificial, drives out the moisture and removes or changes the albuminous substances. Natural seasoning is preferable, leaving the timber stronger and more durable. Water seasoning removes almost all the sap by immersion in water for about two weeks, after which it is dried. Boiling, steaming, and hot air process are also used.

Durability.—Timber lasts best when kept or used in a dry and well ventilated place. Its durability depends upon its protection from decay, the most serious causes being the wet and dry rot, and from the attacks of worms and insects. Timber kept constantly dry, or at least practically so, and in well ventilated positions, will last for centuries. Timber kept constantly wet in fresh water, under such conditions as will exclude air, is also very durable. Timber in damp situations is very likely to decay; yet its durability may be increased by thorough seasoning, by keeping a constant circulation of air about it, or by covering it with paint, varnish or pitch. Timber alternately wet and dry gradually wastes away. Timber constantly wet in sea-water is as desirable as in fresh water, but is liable to be eaten into by small marine worms. There are several special processes of preserving timber.

STONE.

Properties.—Essential for the use of stone as a building material are strength, hardness, durability and ease of working. These are determined by experience or actual experiment. In general, when the texture is uniform and compact, the grain fine, the color dark and the specific gravity great,

the stone is of good quality. Cracks, cavities, presence of iron (shown by rusty discolorations) render it unfit for use. A coarse stone is ordinarily brittle, difficult to work, and more liable to disintegrate than that of a finer grain.

Strength.—Among the stones of the same kind, the strongest is almost always that which has the greatest specific gravity.

Hardness.—May be ascertained by actual experiment. It is an essential quality in stone exposed to wear by attrition. Stones become softer and more friable by the absorption of water.

Durability.—Implies the power to resist wear and tear of atmospheric agencies, capacity to sustain a high temperature, and ability to resist the destructive action of fresh and salt water. As a rule, among stones of the same kind, those which are fine-grained, absorb least water, and are of greatest specific gravity, and also almost durable under ordinary exposures. Examine at or near the quarry rocks of the same kind, which have been exposed for a long time to variable atmospheric conditions, to determine the weathering power of the stone in question.

Ease of Working.—Is a property to a certain extent the inverse of the others. Ease of cutting or hammering into shape implies softness or a low degree of cohesiveness between the particles. Experience and good judgment are required to strike a medium between the conflicting qualities.

Varieties of Building Stones.—As building material, stones may be natural or artificial. 1. NATURAL STONES are divided into three classes:

I. **Silicious Stones.**—In which silica is the principal constituent; in general their structure is crystalline-granular, the grains being hard and durable. They emit sparks when struck with steel, and do not usually effervesce with acids.

Granite.—(Syenite, Granite and Gneiss). This stone ranks high by reason of its superior strength, hardness and durability, and is especially suitable where great strength is required. It does not resist high temperatures very well, while its hardness makes the stone cutting expensive. Gneiss having the mica more in layers, presents a more stratified appearance, and may be broken into thin slabs or blocks. A Granite should be selected of fine grain, even texture, and its constituents uniformly disseminated through the mass. It should be free from pyrites or any iron ore which will rust and deface if not destroy the stone on exposure to the weather. The feldspar varieties are the best and the syenitic most durable. Carefully examine the rocks in and around the quarry to obtain an idea of its durability.

Mica Slate.—Has its composition much the same as Gneiss, and breaks with a glistening or shining surface. The compact varieties are much used for flagging. Hornblende Slate resembles Mica Slate, but is tougher.

Steatite or Soapstone is a soft stone easily cut by a knife, and greasy to the touch. It is not suitable for ordinary building purposes; but on account of ease of working and refractory nature, is used for fire-stones, furnaces and stoves.

Sandstone.—Is a stratified rock consisting of grains of silicious sand, arising from disintegration of silicious stoness cemented together by some material, generally a compound of silica, alumina and lime. It has a harsh feel and dull shades of color, from white to yellow, red and brown, to almost black. Its strength, hardness and durability vary between wide limits. The least durable sandstones contain the most argillaceous matter. The best sandstone lies in thick strata, from which it can be cut in blocks showing faint traces of stratification; that easily split into layers, is the weaker. It should be firm in texture, and not liable to peel off when exposed, and should be free from pyrites or iron sand which rust and disfigure the blocks.

Place the strata in a horizontal position, so that any water which may penetrate between the layers, may have room to expand or escape. Almost all varieties of sandstone yield readily under the chisel and saw, and split evenly, hence it is often called free-stone.

Other varieties of silicious stones besides those named as porphyry, trap or green-stone, basalt, quartz, rock (cobble stone), buhr-stone, etc., are used for building and engineering purposes, and are eminently fit, either as curbstone or rubble as far as strength and durability are concerned.

2. **Argillaceous or Clayey Stones.**—Are deficient in the properties of hardness and durability, and unfit for building purposes. Roofing slate is a stratified rock of great hardness and durability. It should split easily into even slates, and admit of piercing for nails without fracture. Its desirable qualities are compactness, smoothness, uniformity of texture, and clear dark color; it should give a clear ringing sound when struck and absorb but little water.

3. **Calcareous Stones.**—Are those in which lime is the principal constituent. It enters either as sulphate or carbonate.

Gypsum.—(Calcium Carbonates), when burnt and reduced to powder, is used as plaster-of-paris. Use only in dry and protected situations, as it absorbs moisture freely, then swells, cracks and exfoliates rapidly.

Limestones.—(Calcium Carbonates), are much used as ordinary building stones, ornamental stone, and form the source of the principal ingredient of cements and mortars. They are easily scratched with a knife and effervesce in acid. Their texture is either granular or compact; in the latter case the fracture is smooth; in the former it has a crystalline granular surface, the finer varieties resembling loaf sugar. Limestones are generally

impure carbonate and are classed into two divisions—those that can receive a polish, and those that cannot—known as marble and common limestone.

Marbles are chiefly reserved for ornamental purposes. Statuary marble is the purest white, finest grain and free from all foreign minerals. Conglomerate marbles are those made up of rounded pebbles, or angular fragments imbedded in common limestone.

The durability of limestone is materially affected by foreign materials they may contain. The presence of clay injures the stone especially when in minute veins. Ferreous oxide and sulphate and carbonate of iron, when present, are also very destructive. Dolomites are magnesian limestones of which those are considered the best which are most crystalline. They are composed of nearly equal portions of the carbonates of lime and magnesia.

II. **Artificial Stones.**—Are imitations of natural stones, made by consolidating fragmentary solid materials by various means; they may be sub-divided as follows:

1st. Those in which two or more solid materials are mixed together and consolidated by baking or burning, as bricks, tiles, etc.

2d. Those in which solid materials are mixed with fluid or semi-fluid substances, which latter, hardening afterward by chemical combinations, bind the former firmly together, as, ordinary concrete, patent stone, etc.

3rd. Those in which solid materials are mixed with some hot fluid substance, which hardens upon cooling, as asphaltic concrete.

Bricks.—Are made of tempered clay moulded to shape and size and hardened by baking in the sun, or by burning in a kiln or other contrivance. They may be either common or pressed, hand or machine made. Their qualities are dependent upon the kinds of earth used, the tempering of this earth, the moulding of the raw brick, and the drying and burning processes, They are about eight and one-half inches long, four inches broad, and two and three-eighths inches thick.

The characteristics of good bricks are regularity of shape, plane surfaces, sharp edges, opposite faces parallel, and adjacent faces square with each other. They should be free from cracks and flaws; regular in form, and uniform in size, and where exposed to great heat, possess great infusibility. They should give a clear ringing sound when struck, and when broken across should show a fine, compact and uniform texture. They should not absorb more than one-fifth of their weight of water.

Tiles are a variety of brick and are known as roofing, paving, and draining tiles. They are required to be stronger and purer than brick, arising from their greater thinness.

Concrete.—Is a term applied to any mixture of mortar with coarse solid materials, as gravel, shells, pebbles or fragments of brick, tile, or

stone. In order to obtain uniformity, a good concrete for the use of hydraulic lime or cement, or both, it is essential—(1.) that the amount of water be just sufficient to form the cementing material into a viscous paste, and that it be systematically applied; (2.) that each grain of sand or gravel be entirely covered with a thin coating of this paste; and (3.) that the grains be brought into close and intimate contact with each other.

ASPHALTIC CONCRETE,—Is a concrete in which the solid materials are united by Mastic, a mixture of common limestone, or similar material, with artificial or natural combinations of bituminous or resinous substances.

METALS.

IRON,—Obtained from the ore by smelting the latter in a blast furnace, is separated from the other substances in the ore and allowed to combine with a small amount of carbon, (from two to five per cent.), forming a compound known as cast iron. The strength and other good qualities of the iron depend mainly on the absence of impurities, and especially of those substances known to cause brittleness and weakness, as, sulphur, phosphorus, silicon, calcium and magnesium.

CAST IRON,—Is valuable as a building material on account of its great strength, hardness, durability, and the ease with which it can be cast or moulded into the best forms for the purposes to which it is to be applied. It is divided into about six varieties according to their relative hardness. This hardness seems to depend upon the proportion and state of carbon in the metal, and apparently not so much upon the total amount of carbon present in the specimen, as on the proportionate amount in the respective states of mechanical mixture and chemical combination.

Gray cast iron is that in which only a little carbon is combined, and almost all of the particles crystalized separately. It is slightly malleable when cold, and yields readily to the action of the file if the hard outside coating is removed. The fracture is a gray and sometimes bluish gray in color. It is softer and tougher and melts at a lower temperature than white iron. White cast iron (specular iron) is that in which all the carbon is chemically combined with the iron. It is very hard and brittle, resists the file and chisel, and is susceptible of a high polish. Its fracture presents a silvery appearance, generally of fine grain and compact. The intermediate varieties of cast iron, as they approach in appearance, partake more or less of the properties characteristic of these extreme varieties. The varieties usually considered best for building purposes, as combining strength and pliability, are those about midway between the gray and the white, but partaking more of the qualities of the gray cast iron.

APPEARANCE OF GOOD CAST IRON,—A medium sized grain of close compact texture. The color and lustre presented by the surface of a recent fracture of gray iron: uniform dark gray color with high metallic lustre indicates the best and strongest; the same color but less lustre indicates a softer and weaker iron; dark and mottled color with no lustre indicates the softest and weakest of the gray varieties. Of the white varieties: light gray color and high metallic lustre, show the iron to be hard and tenacious; as the color approaches white, hardness and brittleness become more marked, when the extreme, a dull or grayish white color with very high vitreous lustre is attained, the iron is the hardest and most brittle.

Testing cast iron for its quality, if a hammer blow produces a slight indentation, without any appearance of fracture, the iron is slightly malleable and of good quality. If, on the contrary, the edge is broken, there is indication of brittleness and a consequent want of strength.

Strength varies with the density of cast iron. Its density depends upon the temperature of the metal when it is drawn from the furnace, the rate of cooling, the head of metal under which the casting is made, and the bulk of the casting. Uniform appearance of the exterior devoid of marked inequality of surface generally indicates uniform strength. Large castings are generally proportionately weaker than small ones.

WROUGHT OR MALLEABLE IRON,—In its perfect condition is simply pure iron. It contains ordinarily more than one-quarter of one per cent. of carbon. It is tough, malleable and ductile, and infusible in ordinary furnaces.

APPEARANCE OF WROUGHT IRON,—The fracture should show a clear gray color, metallic lustre and a fibrous texture. A crystalline structure shows, as a rule, defective quality. Blisters, flaws and cinder holes are defects due to bad manufacture. Its strength is variable, depending not only on natural qualities, but upon the care bestowed in forging, and the greater or less compression of its fibres when it is rolled or hammered into bars.

FORMS,—Bar-iron, Round-iron, Hoop and Sheet-iron and Wire bars are usually rectangular or square in cross section. Other forms are the T, H, I and L cross-sections called T-iron, H-iron, etc. Inverted U section and channel iron are frequently used. Corrugated iron is sheet-iron of a modified form, by which its strength and stiffness are greatly increased. Iron wire is drawn through circular holes in a metal plate, while round iron is rolled to obtain the requisite cross-section.

STEEL,—The hardest and strongest of the metals, is a chemical combination of iron and carbon, standing between wrought and cast iron. The differences between wrought iron and steel in their physical properties, are largely due to the process of manufacture. The term steely-iron, semi-

steel or mild steel has been applied when the compound contains less than one per cent. of carbon, and steel when containing more than this, and less than 2 per cent. or more is present, the compound is termed cast iron as before stated. Steel is made from iron by various processes, which are of two general classes: (1) in which carbon is added to malleable iron, (2) in which a part of the carbon is abstracted from cast iron. The different kinds of steel are known by names given them either from their mode of manufacture, their appearance, some characteristic constituent, or from some patented process; such as German-steel, blister-steel, shear-steel, cast-steel, tilled-steel, puddle-steel, granulated-steel, Bessemer-steel and Siemens-Martin-steel.

THE DURABILITY,—Of constructions in these metals is, like those in wood subject to the same general conditions. They may be exposed to the air in a dry place, or in a damp place; be kept alternately wet or dry; or be entirely immersed in fresh or salt water. Corrosion is more rapid and destructive under exposure to alternate wetness and dryness than in either of the other cases. It is best to completely imbed the iron in brickwork or masonry to preserve it from rust. The lime in the mortar is also a good preservative. Iron-work must necessarily be protected, and the methods in common use are painting, japanning, galvanizing, and by using linseed oil and coal-tar.

COPPER,—Possesses great durability under ordinary exposure to the weather. From its malleability and tenacity it may easily be worked into thin sheets and ornamental forms.

ZINC,—Is used much more than copper in building, on account of its cheapness and great durability. It finds extensive use in the form of galvanized-iron work.

UNITING MATERIALS.

Iron and wooden structures usually have their component parts united by straps, pins and like fastenings. These will be considered in another part, on Framing. In stone structure limes, cements and mortars are chiefly used as the Uniting Materials.

LIMES.

Calcining the limestone dries off the carbonic acid, leaving lime as a product. There are three leading varieties: (1) common or air-lime, of which a watery paste will harden only in the air; (2) hydraulic lime, and (3) cement, because a watery paste of either will harden under water. Limestones usually contain silica, alumnia, magnesia, etc. If not more than ten

per cent. of these impurities is present, it will produce common lime when calcined. Those limestones containing more than ten per cent. of these impurities, will, when carefully calcined, produce a lime of hydraulic properties. The calcination or burning process is usually carried on in a suitable kiln. The intermittent kilns have all the fuel at the bottom with the limestone built up over it. The perpetual or draw-kiln has the fuel and limestone placed in alternate layers.

(1). LIME,—Common lime, air-lime, quick lime, caustic lime, is amorphous, infusible, somewhat spongy, highly caustic, specific gravity about 2.3, and possesses much avidity for water. Slaking the lime with water makes it ready for use in making mortar. The slaking is accompanied by evolution of heat, swelling, bursting into pieces and crumbling to a fine powder of which the volume is nearly three times its original bulk.

(2). HYDRAULIC LIME,—May consist chiefly of clay or of silica mixed with the carbonate of lime. It slakes more slowly with less heat, and its increase in volume rarely exceeds one-third.

(3). HYDRAULIC CEMENT,—Is made from limestone containing more than twenty and less than forty per cent. of the above named impurities,—alumnia, silica and magnesia. It will not slake when made into a paste with water, and will harden or set under water.

MORTAR.

Common mortar is made of common lime and hydraulic mortar of hydraulic lime or cement. Hardened mortar is an artificial stone, as such it should have all the good qualities of good building stone—strength, hardness and durability. The qualities vary with the equality of the lime or cement used, the kind and amount of sand, the method and degree of manipulation, and the position (moist or dry) in which the mortar is used.

THE PROCESS,—Usually followed is to slake the lime first, by throwing in the lumps first as they come from the kiln, enough water to reduce to a paste. The sand enters as a mechanical mixture, lessening the quality of the lime required, increasing the resistance to crushing and lessening the shrinkage during the drying of the mortar. On the other hand, it is detrimental to the tenacity of the mortar, and if too much sand is used, the mortar will crumble when dry. The proportion of sand to lime varies with the quality of the lime and uses for the mortar. About two and one-half parts of sand to one part of pure slaked lime in paste is a good proportion. The ingredients are incorporated by manual labor or machinery.

SETTLING,—Of mortar is caused by its slowly hardening in the air from surface to the interior, by drying and the absorbtion of carbonic

acid. It has really set when it cannot be altered without fracture. Mortar adheres to other materials according to the nature of the material, its texture and the state and character of the surface to which the mortar is exposed. The materials to be joined should be thoroughly moistened, slow drying insured, and the mortar used stiff, yet plastic.

The hardness, strength and durability of mortar is best tested by experience. The principal causes of deterioration are: (1) Changes of temperature, causing expansions and contractions, (2) alternation of freezing and thawing, cracking and disintegrating the parts so exposed.

FOUNDATIONS.

The term foundation designates the lowest portion or base of any structure. The bed of the foundation, that upon which the structure rests, may be natural or artificial. Yielding of the foundation may be caused by sliding on its bed or turning over about one of the edges. When the bed is of the same material and strength throughout and the pressure evenly distributed over it, it will not turn, while the settling, (which always exists to a certain degree) will be uniform throughout. On the other hand, with a bed of varied material and strength, or when the centre of pressure does not coincide with the centre of the figure of the base, there will be unequal settling, with cracks and ruptures, and probably, destruction of the work. The main object is to prepare the bed of the foundation so as to reduce the settling to the smallest amount, and at the same time prevent this settling from being unequal.

1. NATURAL BEDS,—Are to be prepared in soil sufficiently firm to bear the weight of the structure. The character of the natural bed is sometimes treated by placing weights (at least twice the estimated weight of the building) in different positions on the site of the proposed building, and noting the settling, its extent and uniformity.

2. ARTIFICIAL BEDS,—Require an artificial arrangement to support the building, on account of softness or want of uniformity of the soil. A foundation built upon a bed of piles is an artificial arrangement often used.

The nature of the subsoil may be determined by digging a trench or sinking a pit close to the site, to such a depth as will allow the different strata to be clearly seen. If boring is resorted to, the various kinds and thicknesses of the strata may be seen by examining the material brought up by the augur.

SOILS,—May be divided with respect to foundation, into:

1. Those whose stability is not altered by saturation with water and are firm enough to support the building, as rock, compact stony earth.

2. Those firm enough ordinarily, but whose stability is affected by the presence of water, as clay, sand, fine gravel.

3. Compressible or soft soils; as common earth, marshy soils.

1st Class of Soils. ROCK,—Is required to be of sufficient area, free from cavities, and thick enough to support the building without danger of breaking. If there is any doubt, a thorough examination into the thickness of the stratum and proper tests must be made. Remove all the loose and decayed portions and level the surface. If portions of the building are at different levels, divide the bed into steps. Fill the fissures with concrete or rubble masonry or throw arches over them. When, in large buildings, some portions rest on rock and some on clay or gravel, there will be irregular settlement and much trouble.

COMPACT STONY EARTHS,—Prepare the bed by digging a trench four to six feet deep, to place the foundation below the effects of frost. If there are parts at different levels, divide the trench into steps. The limit for a firm soil of this class is about 3500 pounds per square foot. To distribute the pressure over a greater surface, increase the breadth of the foundation courses. This increase of the breadth, called *spread*, or footings, is made one-and-one-half times the thickness of wall, in compact strong earths; in ordinary earth or sand, the footings should be about twice the thickness of the wall.

2nd Class of Soils. Prepare a trench as before. Since this class of soils is affected by saturation with water, drain the ground thoroughly before beginning work, and arrange the trenches so as to discharge all the water. Expose the soil to the air and weather as little as possible. If the soil for the bed rests upon another which is compressible, or liable to yield laterally, reduce the weight on each part by distributing over a large bearing surface. Lateral yielding may be prevented by enclosing the work within a curb of piles, or similar means.

3rd Class of Soils. SOFT EARTHS,—Must be prepared, as in the other cases, by digging a trench deep enough to place the foundation courses below the action of frost and rain. Level the bed of the trench and cover with a bed of stones, sand or concrete, to prevent unequal settling. Distribute the weight as uniformly as possible.

COMPRESSIBLE SOILS,—Require a foundation of piling in almost all cases. If the firm structure beneath the compressible soil can be reached by piles, it is best to drive them through the soft soil into the firm soil beneath. The tops of the piles are cut off to a given level, fastened firmly by heavy timbers, and a platform laid on top. The foundation courses of the building rest upon this platform.

MASONRY.

According to the material used, masonry may be designated as stone, brick and mixed masonry. From the manner of preparing the material we further classify masonry into *rubble* work, in which the stone is used largely as it comes from the quarry; *cut-stone* or *squared* stone, in which the stone is more or less dressed to the required shape; *Ashlar* work, in which the beds and joints are accurately squared and dressed. While according to the mode of laying the blocks we have regular and irregular masonry.

GENERAL PRINCIPLES OF MASONRY CONSTRUCTION.

1. The form and proportions of almost all masonry work are determined by the amount and kind of strains it is required to resist.

2. The work should be arranged in a series of courses, perpendicular, or as nearly so as practicable, to the direction of the force or forces which they have to resist.

3. Avoid long continuous joints, especially when these joints are parallel to the direction of the force or forces acting upon them.

4. To use the blocks to the best advantage, frequently break joint.

5. Use the largest blocks in the foundation and lower courses.

6. Lay the lower courses, the force acting vertically, on their natural bed; that is, so that the pressure shall be perpendicular to the layers of the stone. If great strength is required in these courses their beds should be dressed square.

7. Moisten all dry and porous blocks before bedding them in mortar, to prevent the mortar from drying too rapidly. Also cleanse the bedding surfaces and the bed of the course from dust, &c.

8. Reduce the space between each block as much as possible and completely fill the joint with mortar.

9. IN BRICKWORK reject all misshapen and unsound brick.

10. Make the bricks of each course break joint with those above and below.

11. Use no "bats" or pieces of brick except when making closures.

STRENGTH OF MASONRY,—Depends upon the size of the blocks, accuracy of the cutting and dressing, carefully-made joints, uniformity of construction, thorough bonding of the work, and the proper distribution of the load.

1. The size of the block varies with the kind of stone and the nature of the quarry. It is usual to make the breadth at least equal to the thickness, while the length is limited to three times the thickness.

2. Accuracy of squaring, cutting, and dressing the blocks ensures their fitting closely, and prevents cracking from any unequal pressure. When the joints are at right angles to each other, and the faces are all dressed at right angles to each other, greater strength is ensured.

3. The joints should be neatly finished or "pointed" on the face exposed to the weather, so as to discharge rain water and prevent destructive elements getting between the blocks.

4. Uniformity of Construction throughout the whole mass of masonry implies that ashlar walls should not have brick or uncoursed rubble backing, and that timber work should not be *directly* set into or connected with masonry work.

5. Thorough Bonding by means of thorough bond stones, headers and stretchers, and breaking joint, ensures stiffness and rigidity.

6. Proper Distribution of Load prevents unequal strains, settling and cracking of the wall. Openings should be near the central portion of the wall or other solid part. Openings should be over openings, piers or columns over piers and columns. Sometimes a uniform slope, called the *batter*, is given to the face or back of a wall.

PRESERVATION OF MASONRY.

THE POINTING,—Of the joints with fine pointing mortar, should be done while the work is fresh, and not after it has set and become hard. A certain amount of settling always takes place in masonry work. Every precaution must be taken to have this settling equal and uniform, throughout. To avoid unequal settling, use the same thickness of mortar throughout, secure thorough bonding, and accurately fitted stone work, and carry up all parts of the wall simultaneously. Sometimes a proof load is tried on the wall before subjecting it to the permanent load.

FROST,—Is the most powerful destructive agent, and is very penetrating. Thoroughly drain the ground in contact with the masonry to at least a depth of the foundation. Mortar exposed to the action of the frost before setting will be so much damaged as to materially injure its properties. During the heat of summer mortar should not be allowed to dry too rapidly. Moisten the stone and brick before and during the process of laying till the mortar gives indications of setting.

REPAIRS,—Should be carefully made by connecting the new work with the old by thorough bonding. Fit the surfaces accurately and use the least amount of mortar compatible with the work of repairing.

GENERAL REMARKS ON MASONRY.

If it is necessary to carry up one part of a wall before the other, the end of the first portion should be racked back; that is, left in a series of steps. The new work should not be bonded to the old till the latter has thoroughly settled. The walls should be perfectly vertical, or at the required "batter" when sloping; each course should be laid level in every direction.

THE BOND should be so arranged as to prevent the vertical joint between any two stones or bricks being in a continuous line with that between any other two. A good bond breaks the vertical joints in length as well as thickness of the wall, ensuring a good lap over one another in both directions, so as to hold as much as possible the different parts of the wall together. A further effect of the bond is to distribute the pressure over a number of stones or bricks below it.

STONE CONSTRUCTION.

STONE CUTTING consists in dressing the surface by cutting draughts or channels around and across the stone with a chisel and then working down the intermediate portions between the draughts by the use of proper tools, usually the chisel, axe and hammer. In working the faces, beds and joints of plane or cylindrical surfaces, no especial difficulty occurs. For conical, spherical or warped surfaces the operations are more difficult. The block is worked to a series of plans or cylindrical surfaces, and then reduced to the required form.

STONE MASONRY AND WALLS.

1. RUBBLE work consists of different shapes of stones, largely used as they come from the quarry: sometimes they are slightly prepared by knocking off the sharp corners and weak angles with a hammer. They are laid with or without mortar. Much care is required in building a rubble wall to have the stones fit one upon the other, and to fill the spaces between the larger stones with smaller ones. The vertical courses should break joint. The mean thickness of a rubble wall should not be less than one-sixth the height. Stones passing through the wall from front to back should be frequently used to bind the parts together.

UNCOURSED or Common Rubble is laid without reference to the heights of the stones.—Fig. 1, a.

COURSED Rubble or Hammered Masonry has the work laid in horizontal courses leveled throughout before another is built upon it. The several courses may be of the same or different heights. The only condition is that each course shall be of the same height throughout.—Fig. 1, b.

2. SQUARED OR CUT STONE masonry has each stone roughly squared or accurately cut, squared or dressed. The blocks are of various sizes, but ordinarily one foot thick, two or three feet long, and have a width from once to twice the thickness. They are used generally for facings of a wall. Fine mortar or cement is used. Each stone should be accurately fitted in its place dry, so that any inaccuracy in dressing may be detected. Fig. 3, a, is RANDOM, and Fig. 3, b, is COURSED ASHLAR. Ashlar work may be backed with brick, coursed rubble or squared stone. In any case, the backing should be coursed evenly with the face. Fig. 3, c. Through bond stones should be often inserted.

JOINTS.—a—Hollow. b—Fillet. c—Half-round.

Additional security is secured by the use of metal connections and clamps, lead plugs, dowelled joints, tongued and grooved and rebated joints, as in joiner's work.

STONE WALLS AND ARCHES.

QUOINS are the corner stones of buildings. They serve to bind the walls well together at the angles, and are often larger or better dressed and finished than the wall stones. Stone quoins to brick or other coursed walls should be of the exact depth of a given number of courses so as to make a good bond.—Fig. 4, Q.

FOOTINGS are projecting courses formed at the bottom of a wall to distribute the weight over a larger area.—Fig. 4, F.

A COPING is a course placed on top of a wall to prevent water entering or soaking into the masonry.—Fig. 5. It projects a little beyond the wall on both sides, and is "throated" by a groove on the under surface and near the wall.

A CORNICE is a large moulding or ornamental course at the top of the wall or building and is of the nature of a coping.—Fig. 4, C.

THE PLINTH is a projecting base to a wall for ornament and stability.—Fig. 4, P.

THE STRING COURSE is a horizontal course carried around the building, chiefly for ornament, but it forms a strong band around the walling and is a source of strength.—Fig. 4, S.

HEADS for openings in walls are usually a horizontal or "lintel" stone,—(Fig. 6, a, b.) or an arch.

JAMBS are the sides of openings either square or recessed to receive the frame of door or window.—Fig. 7.

REVEALS are the portions of the sides of the openings left in front of the recesses for the frames.—Fig. 7, a, b.

SILLS for doors or windows are single slabs of stone forming the base and supporting the wooden sill of the sash frame.—Fig. 6, c, d.

WOOD BRICKS, Slips and plugs are sometimes built into the wall for nailing the necessary woodwork in position.

FORMS OF ARCHES.

1. Straight or flat arch, Voussoirs (the arch stones) radiate towards the centre, found by describing an equilateral triangle on a, b, Fig. 8.

2. Segmental arch; arc less than a semi-circle.—Fig. 9.

3. Semi-circular arch; arc equals a semi-circle.—Fig. 10.

4. Horse-shoe arch; are greater than a semi-circle.—Fig. 11.

5. Elliptic arch, especially used for wide span and little height. Joints are to be along normals to the curve.—Fig. 12.

6. Gothic, or pointed arches are made up of two or more curves (usually circular arcs), and have a pointed crown.—Figs. 13, 14 and 15.

The Lancet, the Equilateral and the Depressed are based upon isosceles triangles,—acute, equilateral and obtuse.

The Tudor arch is a form of the Gothic, but of two or more circular arcs on each side.—Fig. 16.

THE ARCH.

PRINCIPLE.—The parts must mutually support each other and the weight upon them, and be in turn supported by the masses from which the arch springs.

REQUIRES 1. That the several parts be wedge shaped. 2. That the joints be along radii of the circle or along normals to the curve of the arch.—Fig. 17.

PARTS OF THE ARCH.

The INTRADOS, or Soffit is the under surface of the arch.

The EXTRADOS, or Back is the outer surface.

The SPRINGING LINE, A. B., is the line from which the arch springs.

The CROWN is the highest point of the arch.

The HAUNCHES are the sides of the arch from the springing line about half-way up towards the crown.

The SPANDRILS are the triangular spaces between the curve of the arch and the enclosing rectangle.

ABUTMENTS are the bodies supporting the arch and from which it springs.

PIERS are supports, from two or more sides of which arches spring.

JAMBS are the sides of piers or abutments.

VOUSSOIRS are the blocks forming the arch, and supported by their mutual pressures—V. V. V.

The KEY, or Keystone is the centre voussoir at the crown.

SKEWBACKS are the upper surfaces of the abutments or piers from which an arch springs, and are so formed as to radiate from the centre. —S. S. Fig. 17.

The SPAN is the horizontal distance from springing to springing—A. B.

The RISE is the vertical height from the centre of the springing line to soffit—D. F.

When the springing line passes through the centre or centres of the curve of the arch, then the

SPRINGERS are the archstones resting upon the pier or abutment, from which the arch springs.—Fig. 19.

YIELDING AND RUPTURE OF THE ARCH.

Since the arch transmits the pressure it receives directly to lateral points of support, it may yield (1) by sliding along one of its joints, (2) by turning around an edge of a joint. The resistance to sliding arises from the friction of the joints and their adherence to the mortar. The usual mode of fracture is for the arch to separate into four pieces, presenting five points of rupture. Arches with the rise equal to or less than half the span, yield by the crown settling and the sides spreading out; Fig. 20. Similar arches slightly loaded at the crown and overloaded on the haunches, and pointed arches usually rupture as shown in Fig. 21. The strains in the arch are produced by the weight of the archstones, the load upon the arch, and the reactions of the supports at the springing line.

BRICK CONSTRUCTION.

Brick walls are classed according to the kind of bond used.

1. Heading Bond consists entirely of Headers.—Fig. 22.

2. Stretching Bond consists entirely of Stretchers.—Fig. 23.

3. ENGLISH BOND shows both on face and back, heading and stretching courses alternately, with "closers" inserted, as shown, to give lap.—Fig. 24, A. and B. This is the best bond for work generally; it gives the most simple combination for longitudinal and traverse strength. Sometimes it is varied by inserting two or more courses of stretchers between the regular courses of headers.

4. FLEMISH BOND shows in every course, headers and stretchers alternately. Every header is immediately over the centre of a stretcher below it. Closers are inserted next the corner headers to give lap.—Fig. 25, A and B.

5. RAKING BONDS may be diagonal or herring-bone. Fig. 26 shows a diagonal Bond; Lig. 27 a single herring-bone, and Fig. 28 a double herring-bone Bond.

Junction of a brick and stone wall, when necessary, may be effected (1) by stones at short vertical intervals, coursed with the brickwork, and allowed to protrude from the stone wall into the brickwork; (2) by having the brickwork penetrate the stonework in blocks, about four courses in depth, and separated by about the same depth from the courses above and below.

BRICK ARCHES are classed according to the brick used:

1. Plain or Rough Brick Arches in which the bricks are not cut or rubbed to form accurately fitting voussoirs radiating from a centre. Mortar joints are wedge shaped.

2. Rough cut, or Axed Arches in which the bricks are roughly cut to wedge shape.

3. Gauged Arches are built of bricks accurately cut to gauge and rubbed down so as to radiate from the centre.

CENTRES for stone and brick arches are wooden skeleton frames upon which the arch is built.

RELIEVING ARCHES are frequently placed over a lintel head or flat arch.—Fig. 29.

COPINGS for brickwork are usually of stone, glazed pottery, fire brick, or terra cotta.

CORBELS of stone and corbelling of brick are often used to project beyond the wall, serving as a bracket or support; Fig. 30.

STRING COURSES in brick walls are frequently of stone or ornamental brick.

CORNICES are produced by "corbelling" out the bricks, and by the use of ornamental brick cornice mouldings.

WOOD CONSTRUCTION.

PRINCIPLES OF JOINTS AND FASTENINGS.

1. Cut the joints and arrange the fastenings so as to weaken as little as possible the pieces of timber that they connect.

2. Place each abutting surface in a joint as nearly as possible perpendicular to the line of the pressure it has to transmit.

3. Proportion the area of each surface to the pressure it has to bear, so that the timber may be safe against injury under the heaviest load occurring in practice.

4. Form and fit each pair of surfaces accurately, in order to distribute the stress uniformly.

5. Proportion the fastenings so that they may be of equal strength with the pieces which they connect.

6. Place the fastenings in each piece of timber so that they shall not shear or crush their way through the timber.

In general, bear in mind the shrinking and settling of the timbers, otherwise pressures will come upon parts not intended to receive them, resulting in crushing or splitting at the points of contact. The simplest forms of joints are the best, so that the parts may be fitted with the least inconvenience.

STRAIGHT JOINTS are those chiefly used in lengthening timber (1) for "ties" or beams in tension; (2) for "struts" or beams in compression; and (3) for beams under cross strain.

1. LAP Joint for Tension,—Fig. 31, BUTT or Fish Joint, for compression,—Fig. 32; fish plates secured on each side by bolts.

2. SCARF Joints to resist Compression; Figs. 33 and 34. Any joint with oblique bearing surfaces is not adapted to resist compression.

3. SCARF Joints to resist Tension; Figs. 35 and 36.

4. SCARF Joints to resist both Tension and Compression; Figs. 37, 38.

5. SCARF Joint to resist Cross Strain; Fig. 39, a, b. Upper indent is square, lower is oblique. A joint will resist cross strain better when scarfed vertically through its depth.

6. SCARF Joint to resist Cross Strain and Tension.—Fig. 40.

ANGLE JOINTS are those chiefly used:—

1. For beams bearing on beams; as the halved joints,—simple, level and dovetail; dovetail, notched, cogged, square and oblique mortise and tenon joints. Tusk and tenon,—Fig. 41.

2. For beams on posts or posts on beams, bridle joints, converse of the mortise and tenon.

3. For struts, with ties or posts; oblique tenon,—Fig. 42; and bridle joint, Fig. 43, indent should always be a right angle.

FASTENINGS are used for making joints more secure; as, wedges, keys, pins,—wood and iron, screws, bolts, straps, sockets, plates, &c.

GIRDERS AND TRUSSES.

Single beams, built-up beams, trussed beams and girders of wood and plate, built-up and bow girders of wrought iron are used to support floors.

GIRDERS should be placed so as to have good firm support at the extremities. They should rest on solid walls or piers, and never over windows or other openings. The ends of all timber girders should rest upon stone templates, and be perfectly clear of the masonry. The ends of iron girders should be bedded in lead or felt. There should be as few riveted joints as possible, and those accessible for riveting.

TRUSSES may be either straight, triangular, polygonal, or curved. Straight trusses are sometimes used for the transverse support of large floors, while the others are for roofs. (Their special application in Bridge Construction cannot be considered here.)

PRINCIPLES AND REQUIREMENTS of the theoretically perfect framed structure or truss.

1. At each joint the parts should be so connected as to leave them free to rotate as though hinged; the frame will, nevertheless, be free from liability to distortion,—that is, no such rotation of the joints can take place.

2. Any one part of the structure may be made longer, or shorter, without thereby inducing stresses.

3. Slight irregularities in the lengths of the parts have no practical effect upon the distribution of the stresses.

4. As many of the braces as possible should be in tension, and the struts should be as short as possible.

For economic distribution of material, place the principal roof trusses a distance apart equal to from one-eighth to one-quarter of the span.

TYPES OF TRUSSES may be divided into:—

1. Those in which a brace radiates from a central point in a truss to each otherwise unsupported point,—Fig. 44.

2. Those in which the braces, &c., radiate from two points in the truss,—Fig. 45.

3. Those having the braces arranged in zig-zag fashion and dividing the truss into the simplest chain of triangles,—Fig. 46.

MODIFICATION OF ROOF-TRUSS ARRANGEMENTS.

The contour of the roof-surface, and the shape given to the tie-bar may be greatly varied, and the appearance of the design much changed, without any change in the relative position of the parts.

1. Common isosceles triangle,—Fig. 47. Slopes vary from a rise of one in two-and-a-half, to one in one-and-a-half, and much steeper for architectural effect.

2. Polygonal, flattened or steep,—Fig. 48.

3. Curved, arc of circle, elliptic or parbolic curves, and Gothic forms,—Fig. 49.

IRON CONSTRUCTION.

Iron has lately come into very extensive use in modern building operations. The principal drawbacks have been the questions of its durability, and safety under fire. To insure these, iron columns and girders are now thoroughly encased in some protecting material, as iron paint, plaster, cement, or firebrick. It admits of the best fireproof construction for floors, especially when the iron beams are filled in between with flat or segmental arches of hollow firebrick.

Solid CAST-IRON plates and bands, hollow cast-iron bases, pillars, columns, ornamental capitals, brackets, &c., are selected to resist *compressive* strains.

WROUGHT AND ROLLED IRON beams, rods, straps, and fastenings are used to resist *tensile* strains. Built-up beams, girders and frames ensure much additional strength without great increase in weight.

GALVANIZED SHEET-IRON is much used for cornice mouldings, troughs, &c.

Sharp angles and *corners* must be avoided in the structural parts of cast-iron work.

The PHOENIX COLUMN is built up of four, six, or eight segments of a circle and riveted along its length,—Fig. 50.

Wrought iron GIRDERS are shown, of T-section in Fig. 51, and of Trough and Box-section in Fig. 52.

The Single Plate Girder is the most simple, rigid and durable for small spaces.

Lattice Girders, made up of a series of triangles, with continuous or built-up flanges at top and bottom are used for longer spaces. Fig. 53, a, b.

The I-section is the most usual in all of these.

For parts in TENSION, tie-rods and eye-bars are chiefly used. Fig. 54.

STRUTS for parts in COMPRESSION are T-shaped and Trough or Box-Shaped.

RIVETED JOINTS.

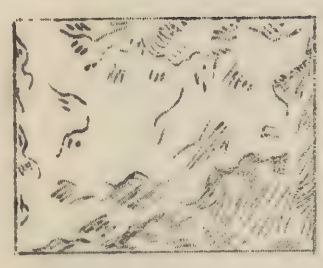
FORMS of Rivets used are Strap rivets, Fig. 55, a; Hammered rivets, b; (pan head); Countersunk, c.

LAP JOINTS,—Fig. 56, BUTT JOINTS,—Fig. 57.

SINGLE RIVETING consists of a single row of rivets as in Fig. 56, a.

DOUBLE RIVETING may be "plain," as in Fig. 56, b; or "Zig-zag" as in Fig. 58. The Chain riveting is formed by lines of rivets in the direction of the stress, and parallel on each side of the joint. The zig-zag or Staggered riveting has the rivets so placed that those of each line divide the spaces between the rivets in the adjacent lines.

STONE CUTTING



A



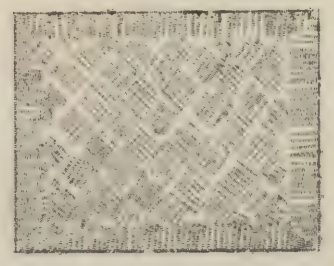
B



C



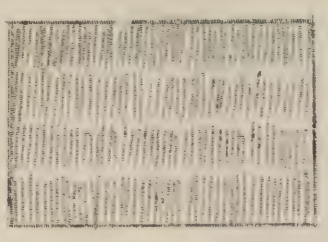
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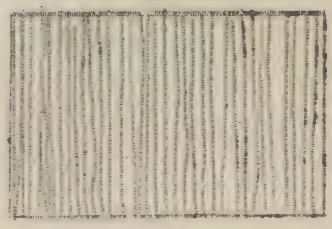
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E



F



G

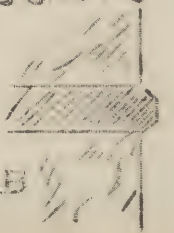
MORTAR JOINTS



A



B

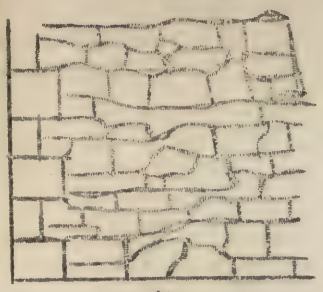


B



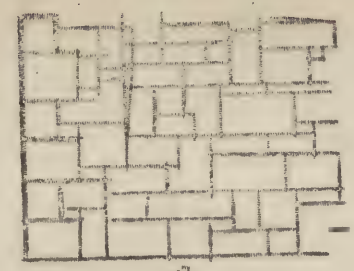
C

FIG 1



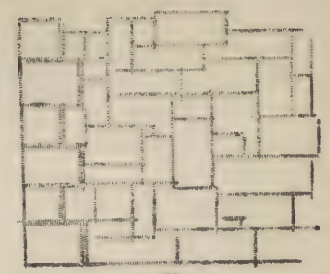
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FIG 2

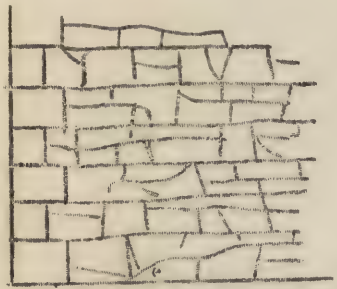


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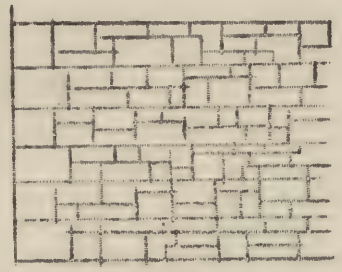
FIG 3



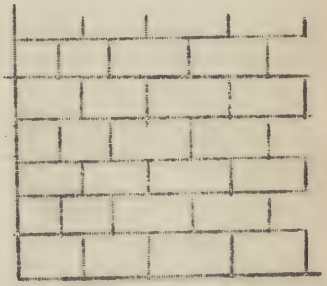
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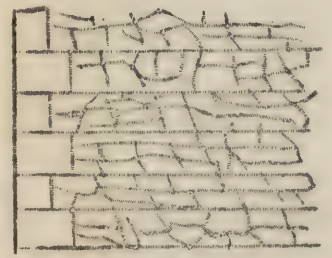
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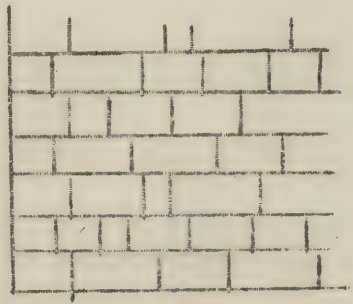
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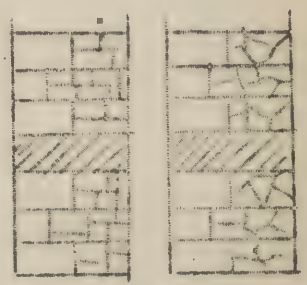
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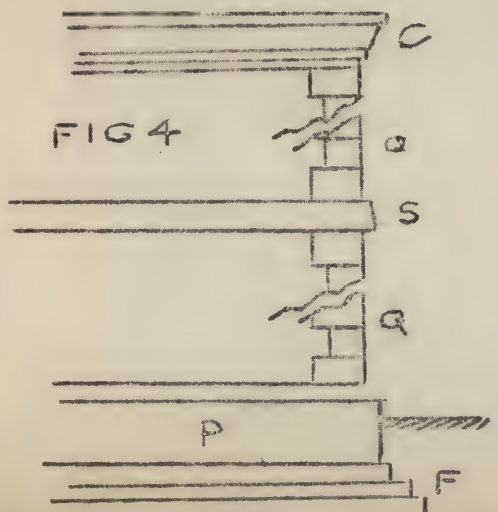


C



C

FIG 4



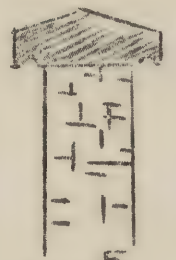


FIG 5

FIG 6



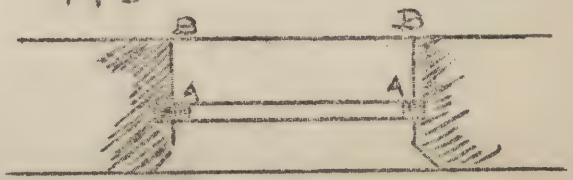


FIG 7

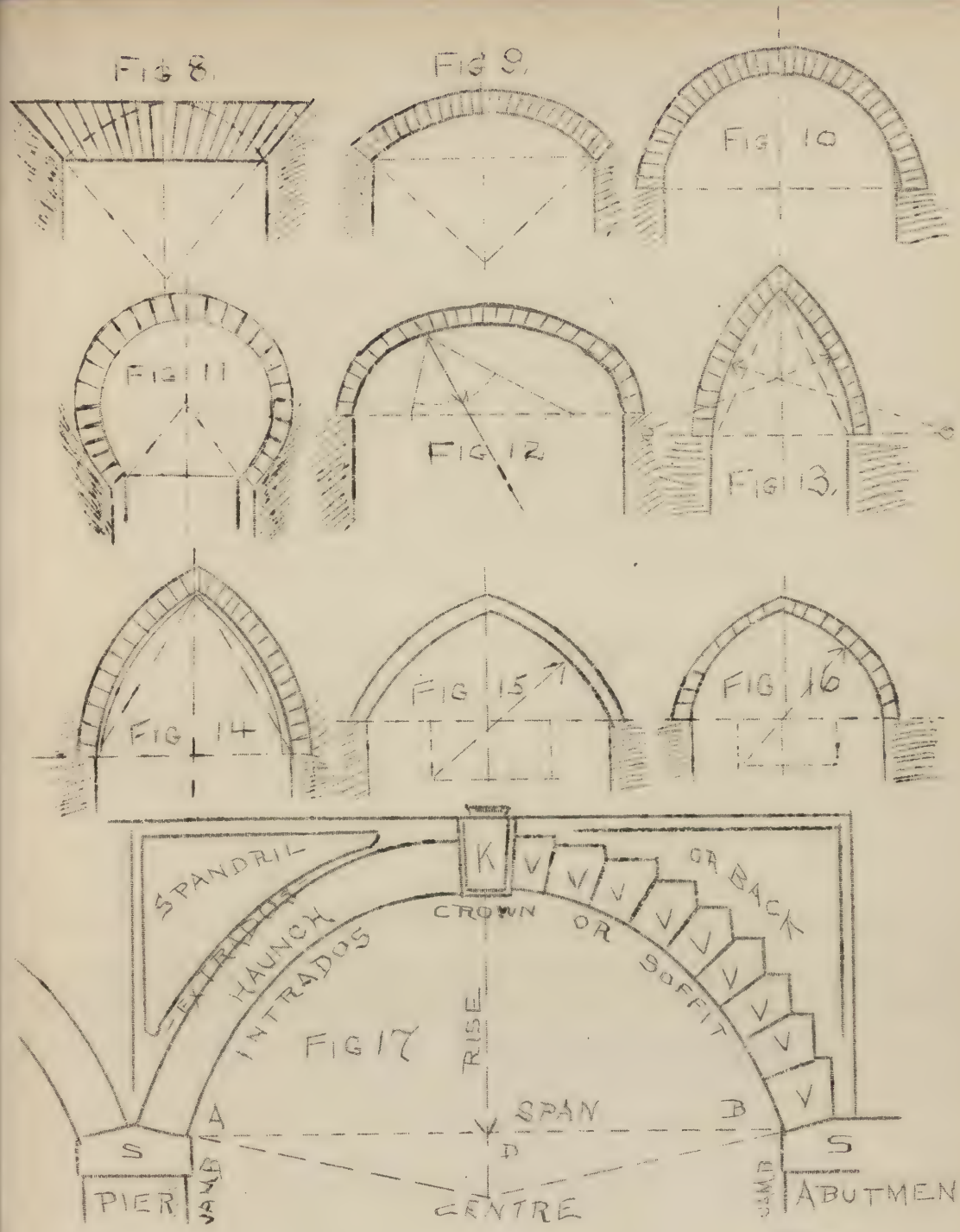
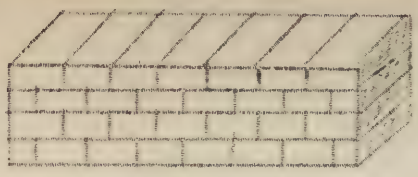
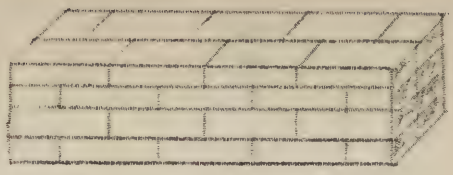

FIG 8.
FIG 9.
FIG 10
FIG 11
FIG 12
FIG 13.
FIG 14
FIG 15
FIG 16
SPANDRIL
EXTRADOS
HAUNCH
INTRADOS
K
V
CROWN
OR
SOFFIT
OR BACK
RISE
SPAN
A
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ABUTMENT
FIG 17
FIG 19
FIG 20
FIG 21

FIG. 22



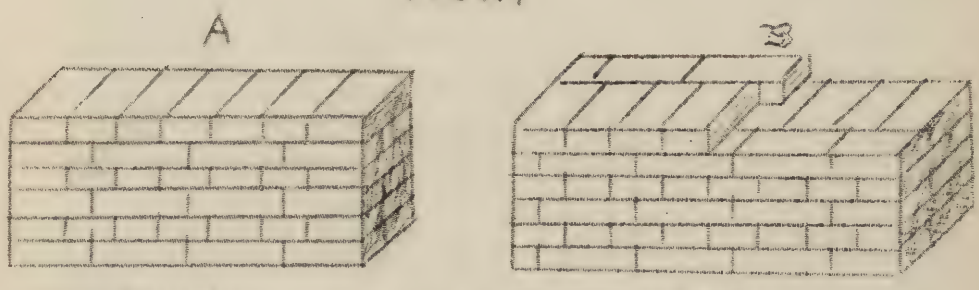
HEADERS

FIG. 23



STRETCHERS

FIG 24

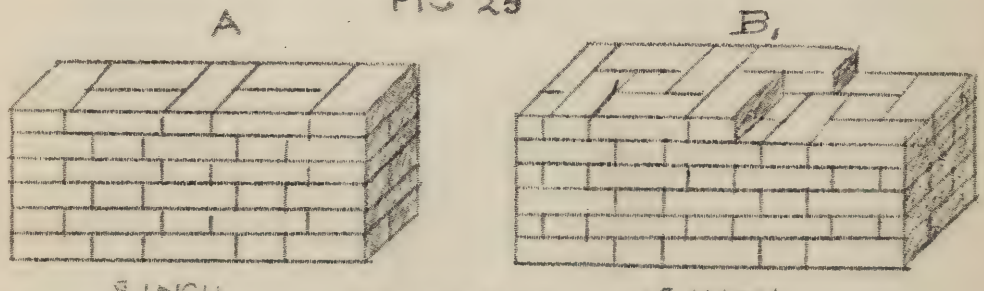


8 INCH

ENGLISH

12 INCH

FIG 25



8 INCH

FLEMISH

12 INCH

FIG. 26.

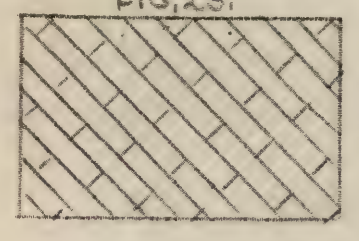


FIG 27.

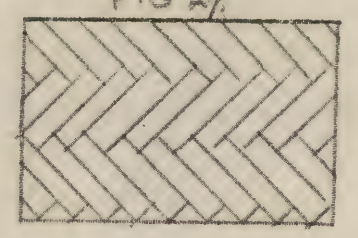
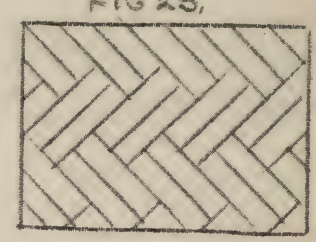


FIG 28.



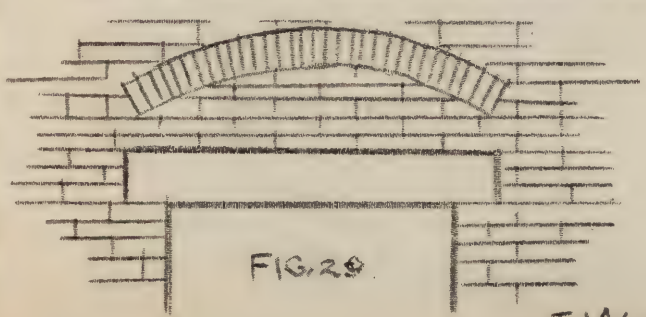


FIG. 29

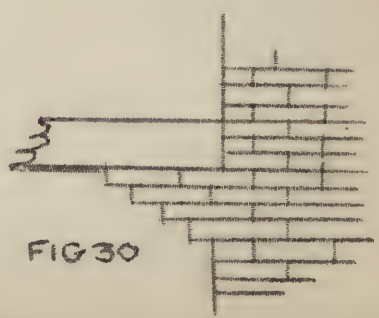
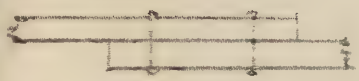


FIG 30

~J.W.~

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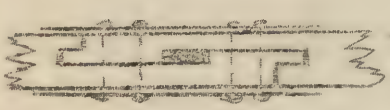
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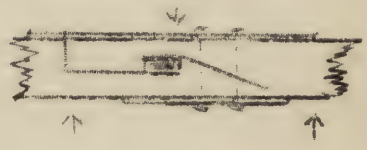


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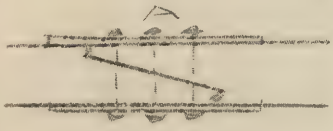
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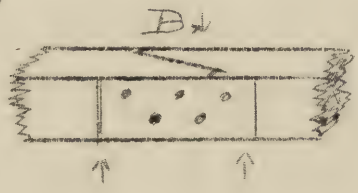


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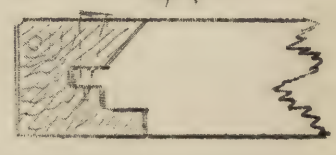


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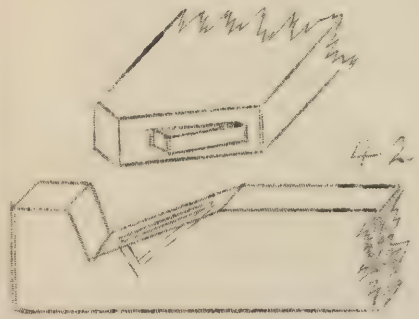




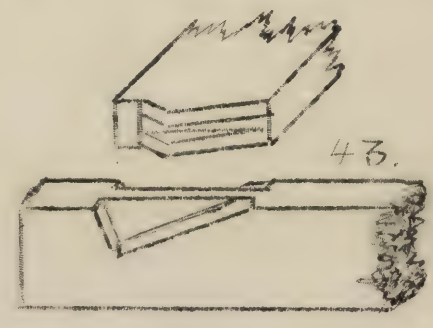
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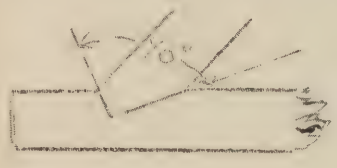


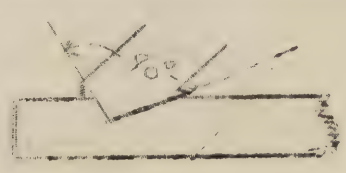
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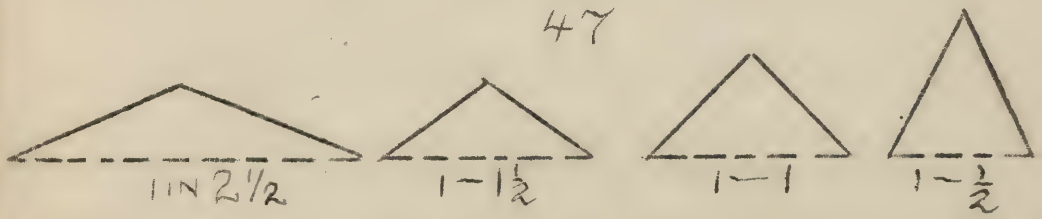
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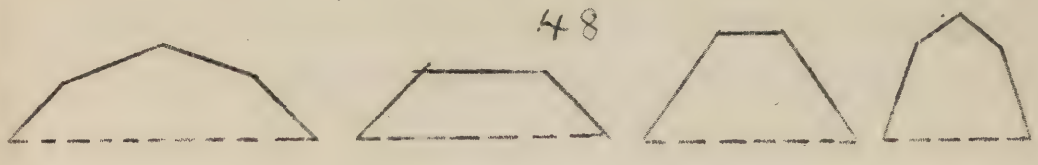
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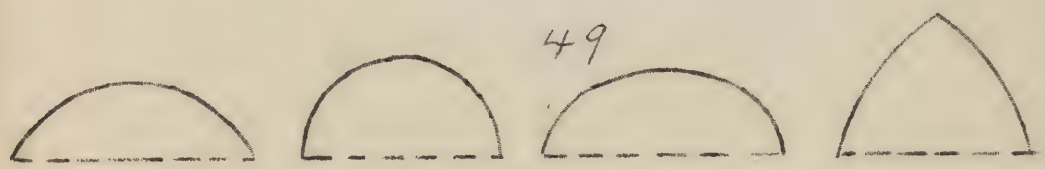
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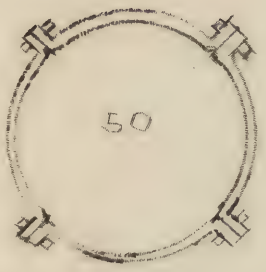


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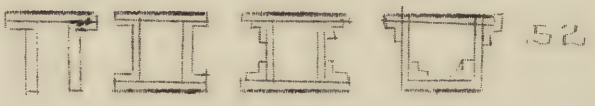


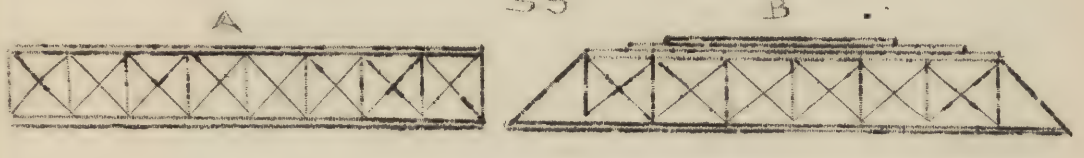
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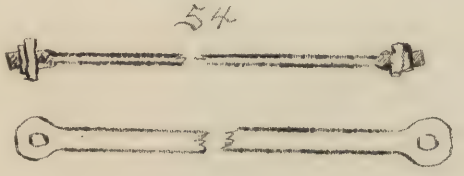



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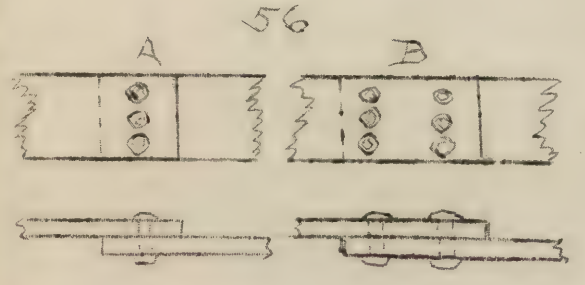

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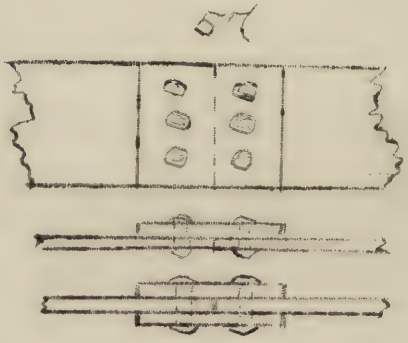

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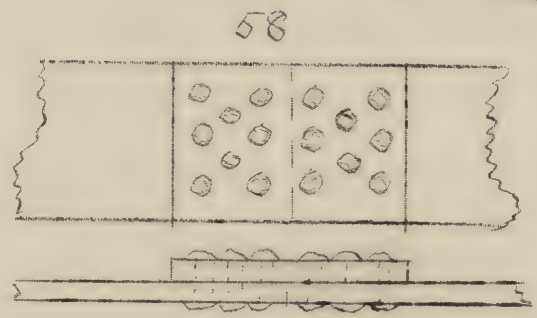

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A
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PHILADELPHIA MANUAL TRAINING SCHOOL.

NOTES
ON
BUILDING CONSTRUCTION
AND
ARCHITECTURE.

BY WM. S. ALDRICH, M.E.

OBJECTS.—1. To present the subject of Architecture from an historical standpoint, and combine therewith the comparative study of the structural and ornamental features of the various styles of Architecture.

2. To familiarize the pupil with the typical forms of historic ornament, and the principles of design and composition found therein.

3. To cultivate the sense of and a taste for the beautiful in Art and Architecture.

HOW ACCOMPLISHED.—1. By short talks and illustrated lectures; study of notes, drawings, charts, photographs, ornamental forms; reference to standard books on the subject.

2. Study of existing typical buildings in Philadelphia and elsewhere, with special reference to the *influences* which Historic Art and Architecture have exercised in their construction and ornamentation.

3. By architectural sketches, drawings and designs from the critical study of historic forms and typical forms in existing buildings.

LIST OF REFERENCE BOOKS.

History of Architecture.—Ferguson.
Discourses on Architecture.—Viollet-le-Duc.
Stones of Venice.—Ruskin.
Seven Lamps of Architecture.—Ruskin.
Gothic Architecture.—Parker; Bloxam.
Analysis of Ornament.—Wornum.
History of Art.—Lubke.
Handbook of Architectural Styles.—Rosengarten.
Lectures on Architecture.—Barry.
Classic Architecture.—Roger Smith.
Gothic and Renaissance.—Roger Smith.
Encyclopædia.—Stewart; Gwilt.
Concise Glossary of Architecture.—Parker.

PART I.

ELEMENTS OF ARCHITECTURAL STUDY.

1.—Definition.—*Architecture* is the art of building according to principles determined by utility, stability and beauty—the art of ornamental and ornamented construction. As a *science* it implies good and substantial building, regulated by the laws and principles of building construction; as an *art* it implies such arrangement of plan, masses and enrichments as shall best impart interest, beauty, grandeur, unity and power. A perfect building combines—

1st.—*In construction*—convenience of arrangement in plan, proper distribution of material, ornamental arrangement with ornamented construction. And—

2d.—*In ornamentation* it combines ornamental arrangement and construction, decorative ornament, sculpture and painting.

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2.—Requirements of Architecture are therefore:

1st.—*Material* requirements, based on utility, as meeting man's necessity for shelter, etc., and stability dependent upon scientific construction, knowledge of which is obtained by diligent study of known laws, aided by judgment, experience and common sense.

2d.—*Æsthetic* requirements, based on beauty as supplying man's taste for decoration, and dependent upon the means of expression which architecture can take advantage of—repetition, symmetry, harmony, size, proportion, direction, subordination, ornament and color—and all of which calls for a knowledge of man's traditions and aspirations as seen in historic art, and a keen perception and observation of nature.

3.—Architectural Design therefore consists in the planning of a building the most suitable and convenient for the purpose required, whose several parts are arranged to produce the most stately and ornamental effects consistent with its use, the applied ornament to be of the best design and used in such a way as to harmonize with the construction and be appropriate to the purpose of the building.

4.—Elements of Construction in Architectural Design.

1st.—*Site* to be located by the chief considerations of utility and beauty; architectural effect of surroundings not to be neglected.

2d.—*Planning* the structure with judicious distribution and disposition of the several parts. The ground plan and disposition of floor plans and interior being fixed upon, the exterior may be best disposed in harmony with it. Simplicity of plan and interior produces simplicity of elevation and vertical section.

3d.—*Materials* obtained in the vicinity or brought from a distance. The kind used determines largely the stability and durability as much as the methods of construction, and the size of material is a main factor. The physical properties of the material and the laws of strength are to be considered, as well as the principles of grandeur and beauty.

4th.—*Structural elements* may be old and typical forms put to new uses, or new and untried forms. The horizontal, or lintel, and the arched constructions are the two great systems of the world. The Hindus say "an arch never sleeps." The architectural effect of a building varies almost inversely to the mechanical ingenuity displayed in its construction.

5th.—*Stability* must be fully insured by the proportions of the several parts being determined by the laws of mechanics and the principles of building construction. There must be inherent equilibrium in all the parts as well as the whole, that the mind may be fully satisfied as to stability. Combined with size it produces grandeur.

6th.—*Durability* should be evident and insured by the use of the best material in the best manner consistent with the most approved principles of building construction, and this under extraordinary as well as ordinary conditions.

7th.—*Sanitary* considerations as to lighting, heating, ventilation and drainage are largely determined by physical and chemical laws.

The more common principles, too often neglected, are:

a. Light should enter from the side or rear or from above the level of the eye. Artificial lights should be well above the head No source of light should be directly in front of the eye.

b. Heating arrangements should be planned and placed so as to aid the circulation of air in the room. Heated air ascends with a velocity proportional to its temperature. Cold air, or air laden with carbonic acid gas, descends and forms a layer of impure cold air over the floor. Hot-air

registers and open fire-places and open stoves produce better circulation and more frequent change of air than closed stoves or warm-water coils or steam-coils in the room.

c. Ventilation in the usual way, by allowing the cold air to enter near the ceiling, and the heated air entering (or the source of heat placed) near the floor on the opposite side of the room, insures good circulation and mixture of air. Deflecting boards or shields spread the entering cold air over the room and insure better mixture of air.

d. Sewage should be run into the sea, or allowed to spread itself over distant farm lands, or be artificially evaporated and burned. All sewage and drainage pipes should be thoroughly ventilated by vents, and ventilating pipes always open to the outside air. All traps and drains should have back-vents to prevent syphonage. All sewage and drainage pipes should be thoroughly and frequently cleaned by flushing with water.

8th.—*Execution* of the structure requires a knowledge of many trades, and should be thoroughly, skillfully and artistically carried out.

5.—Elements of Decoration in Architectural Design.

1st.—*Ornament* may be divided into two kinds:

a. Constructive Ornament, such as capitals, brackets, vaulting shafts, etc., which serve to explain, emphasize and give expression to the construction.

b. Decorative Ornament, such as moldings, frets, foliage, natural forms, etc., which give grace and life to the structural parts and forms themselves, and serve to enrich the constructive ornament. Ornament seems most proper when confined thus to the decoration of structural parts.

2d —*Forms or Elements in Ornamental Art* are:

a. Geometric or absolute, consisting of simple or intricate combinations of straight and curved lines, in a pleasing and orderly way, or in a fanciful and mysterious way.

b. Conventional, derived from previous forms in historic ornament, or derived directly from natural forms.

The natural treatment of these natural forms is that in which the details and order of growth in nature are both imitated. The conventional treatment of these natural forms is that in which the details and order of growth are fancifully, ideally or conventionally treated. The details of all the great ornamental styles are largely derived from nature, but for the most part conventionally treated. The constructive and decorative arts of Architecture should copy the *processes* of nature rather than her forms.

3d.—*Classes of Ornamental Art:*

a. Symbolic, in which the treatment of the forms is such as to appeal to our feelings and the spiritual side of our nature; the elements are chosen for the sake of their signification. Certain details become standards and full of religious significance.

b. Æsthetic, in which the treatment of the forms is such as to appeal to our understanding and the intellectual side of our nature; the elements are chosen for their intrinsic beauty and their effect on our perception of the beautiful. The details as well as the whole possess certain symmetry of form and harmony of color.

4th.—*Material and its Treatment* largely determine the peculiar charm or characteristic of ornament.

It may be flat or raised, lightly carved or deeply undercut, but in either case the effect is produced by contrast. In the flat it is a contrast of light and dark or color—a contrast of surfaces; in the raised it is a contrast of light and shade—a contrast of masses.

5th.—*Color* should be applied with discretion and kept subordinate to form or outline. Though now chiefly confined to interiors, it was early used on exteriors as well, in some instances very effectively. It may be in the form of applied color pigments, or of colored material artistically wrought into the surface work.

6th.—*Sculpture and Painting* copy the forms of nature. They have contributed to the harmony of the decoration and ornamentation of architecture in all ages, and especially when consistent with the purpose of the building and the tastes of the people.

6.—Elements of Architectural Composition.

1st.—*Principality* requires that one particular part or feature shall be more prominent than all the rest, and that the others shall be grouped with it in a degree of subordination.

2d.—*Size*, mass, or vastness of proportion excites feelings of awe and of the majesty of human power. Alone it is insufficient, but combined with harmony and symmetry it produces grandeur.

3d.—*Proportion* implies the use of certain ratios in the principal dimensions of a building, and a certain proper relation to buildings and objects around it. Good proportion requires to be modified by every varying exigency of design.

The proportions of a cube, of two cubes placed side by side, or dimensions increasing by one-half, please the eye more than random dimensions possibly can. If one dimension is changed the appearance of all the others is changed. Strongly marked horizontal bands in construction or decoration make a room appear long and low. The reverse is true for heights. Externally, strongly marked vertical lines of construction or decoration increase the apparent height, while leading horizontal lines or bands will bring down the apparent height. Great apparent length may be obviated by projections or breaking up the length into square divisions.

4th.—*Harmony* implies the general balancing of all parts of the design —the straight, the inclined and the curved. It produces a certain unity or uniformity throughout, and groups many parts into one continuous and symmetrical whole. There is to be harmony of sentiment, harmony of knowledge and technical harmony. It is true proportion applied to the mutual relations of details to each other and to the whole. It requires supported parts to have adequate ratio to their supports, solid portions a proper relation to solid parts, and openings to openings.

5th.—*Symmetry* implies a certain balance and uniformity in plan and elevation. Such symmetry of general features, with variety of detail, as is seen in leaves, trees, animals and other natural objects, seems most fitting. Certain leading directions being selected, the several parts and details are to be arranged about these lines so as to produce symmetry, or balance and harmony.

6th.—*Repetition* seems one of the simplest principles of composition, yet it requires care to prevent its being carried too far and becoming meaningless and monotonous. To this end a series of repeated forms are often interrupted at intervals by other and different forms. The greatest variety is permissible in the details of repeated architectural elements or forms. Sometimes it is alternation of form with repetition of groups of forms.

7th.—*Contrast* is aided by this alternation of forms, as well as by the law of principality. A curved line is set off by a straight one, a massy form by a slight one, and so on. Judicious contrast increases the interest and value of any composition.

8th.—*Fitness* and consistency may seem opposed to contrast, but it is so in all true composition, one principle helps another at the same time that it counteracts its extreme tendency. Fitness is that peculiar combination of the elements of composition which makes the building pleasant and agreeable at first sight, thoroughly in keeping with itself and its surroundings, and the most completely adapted to its purpose and use, though it is

dictated by æsthetic considerations far more subtle and profound than the simple question as to whether the building is beautiful or ugly.

9th.—*Associations* are inevitable. With massive, square and angular forms the mind associates strength and power; with circular, elliptical and higher cures—softness and elegance. In general the former are placed below, the latter above. Besides these æsthetic associations there are the physical, moral, intellectual and spiritual associations. The building should meet the requirements of its existence and those of the community, and should express and share its hopes and fears. For the time the building should so belong to that community as to be a complete index of its feelings and impulses, its tastes and aspirations. These associations may be so true and faithful, characteristic and powerful, as to give distinct architectural style to the building and the age in which it was built.

10th.—*Style in a building* is good architectural composition, in harmony with the age which erected it, with the requirements of its use and the means of its execution.

7.—Style in Architecture signifies the characteristic differences which exist between the architectural works of the various nations. Since architecture is the material expression of the wants, feelings and sentiments of the age in which it is created, its *style* is the peculiar form that expression takes under the influence of climate and materials at command, public interests and private needs, and education and religion. Style is but another name for character, and so depends upon that which is peculiar to the architectural character of any age or nation.

8.—The Styles of Architecture which will be considered in these notes are those which have most influenced the world of art and architecture, whose influences have been powerful and lasting, and many of whose great buildings and structures have remained even unto this day as monuments of the taste and skill of their architects. Such are the Egyptian, Assyrio-Persian, Greek and Roman of the ancient world; the Byzantine, Saracenic, Romanesque and Gothic of the middle ages; and the Renaissance of modern times. Of course there are many varieties of these styles. It will only be possible, in the brief space marked out, to consider the chief characteristics of each of these great styles at their full development and the most brilliant period of their history.

9.—Growth.—Architecture has grown with the development of the human race. In every country it has been a growth of the soil, so to speak: (1) as adapted to the climate; (2) as adapted to the materials found there; (3) partly the outcome of the national character of its inhabitants, and (4) of the influences which race, colonization, conquest, commerce, education and religion have brought to bear. Each age, each great style, has left something of an inheritance to those who should follow. In almost all styles there is some structural element or motive for decoration derived from the preceding style. These may have been changed or have suggested new forms, but the elements are few and the motives simple, and when separated and analyzed almost every one of these can be traced back to the architecture of the ancient world.

10.—Historical Treatment of Architecture is therefore necessary if we would understand the relation and dependence of each style upon the preceding styles and the whole as it has affected European civilization. All European architecture, good and bad, old and new, is derived from

Greece through Rome, and colored and perfected from the East. The history of architecture traces each form from its origin, noting the differences which existed and the influence one style has had upon another as the different styles have developed. Two main divisions naturally arise in the consideration of any style; namely, the structural and the ornamental characteristics.

11.—Structural Characteristics.—Though every building is made up of floors, walls, roof, openings and ornaments, yet it is the way openings are covered that usually determines the other structural elements.

1st.—*Lintel* or Beam Construction. Supports and columns could not be placed far apart, and therefore we have colonnade construction, with massive beams of wood or great lintels of stone; as in the Egyptian, Assyrio-Persian, Greek, and partly in the Roman styles.

2d.—*Arched* Construction, at first the round arch, though the Assyrians are supposed to have used round and pointed arches in underground passages and culverts. The *Round arch* is typical of the Roman style (in which it is often used in combination with the column and lintel of the Greek), the Byzantine and its domical construction, and the Romanesque as it developed out of the Roman basilica. The *Pointed arch* is typical of the Saracenic and Gothic styles, though round and horseshoe arches are to be seen along with pointed arches in many buildings in the Saracenic style.

12.—Ornamental Characteristics.—Though there are many varieties of ornament in every building possessing real style, such as moldings, brackets, columns, capitals, cornice, etc., yet it is the kind of capitals that go far towards determining the style and characteristics of the other ornamental elements.

1st.—*Convex Capitals*, from the bud capital of the Egyptian style to the Doric of the Greek, which becomes the root of all Romanesque, massy-capitaled buildings—Byzantine, Lombard and Norman varieties. As a style it is rather severe, almost Spartan in the simplicity of its early work, and somewhat symbolic in its ornamental details.

2d.—*Concave Capitals*, from the lotus capital of the Egyptian style to the Corinthian of the Greek, which becomes the root of the Gothic—early English, French, German, Tuscan, etc. As a style it is rather florid, showing judicious conventional treatment of natural forms.

In the transition periods the structural and ornamental forms are rather straight and linear, the root or centre of both the great forms.

The Egyptians gave the shaft, the Greeks perfected its proportions; Rome gave the arch, and the Arabs pointed and foliated the arch.

Beauty does not reside in pointed or round arches, bracket capitals or horizontal architraves, but in thoughtful appropriateness of design and intellectual elegance of detail.

13.—The Architectural Periods of each style are four, quite distinct and noticeable in the architectural history of every nation.

1st.—*Period of Inception.*—The structures are simple and massive, possessing great stability and inherent durability. The material is used in large blocks, feats of strength being undertaken rather than skillful construction. The elements of construction are few and simple—a massive stone lintel or a simple round arch. The forms are massive, angular and square in keeping with the simple conceptions and character of the people. Harmony, proportion and symmetry are unknown, as these are the children

of a later age, a period of culture and refinement. There are simple fitness and distribution of parts to meet immediate wants. There is little if any ornament. The whole work of this period is forever associated with the early struggles of the people against physical wants. In later ages this period may be termed the *Transitional* from past forms to new and more difficult ones, yet making use of what the past has bequeathed.

2d.—*Period of Growth.*—The structures are less massive and durable, but none the less stable. The material is smaller in size, perhaps finer in quality, and worked with more care. The elements of construction with some remain the same, with others they are put to new and untried uses, for this is the age of experiment and invention, in forms structural and ornamental. Rounded forms and skillful combinations show a gradual and growing appreciation for harmony, proportion and symmetry. Constructive ornament and some decorative, with the use of color, sculpture and painting, may be noticed. The associations are as strong as formerly, and give the structures of this period real style.

3d.—*Period of Full Development.*—The attention of the people, by reason of their culture and refinement, is now given almost wholly to the elaboration of their ornament and the enrichment of their buildings upon exterior and interior. Scientific principles of construction have now been fully worked out. The mass of the material has been much reduced; stability and durability are at least insured for the age that lives. The structural elements are more complex, and structural and ornamental forms are fully developed into a satisfactory system. Harmony, proportion and symmetry receive full recognition. Ornament of all kinds, color, sculpture and painting, are very fully worked out. There is less imitation of nature than in the second period, the forms being more refined and conventionalized. The associations and fitness are so true and faithful that the architecture of this period possesses distinctive style and is taken as the characteristic style of the nation.

4th.—*Period of Decline.*—There is an almost utter disregard of all the principles of construction and decoration so carefully and fully worked out in the preceding brilliant period. Perhaps in no feature are the neglect and indifference so marked as in the ornament and sculpture and painting. The materials are small in size and more perishable than in any preceding age. While the works of the first period were largely built for permanence, even if possible for an eternity of duration, this last period cares only for the present use. Many natural causes, within and without, bring the architecture of this period into disrepute and decay. With some nations it is war and conquest; with others it is luxury, extravagance, magnificence, sensuality and political complications which cause the sudden and rapid decline of art and architecture. Out of the ruins another people, another nation take what fragments they admire and build thereon a new style, itself to grow, become fully developed and decline. Such is the life of nations as of the individuals composing them. And history goes on repeating itself, with a mite contributed to the universal progress of the human race.

14.—Architectural Analysis is based upon the foregoing general observations, and upon the particular principles and elements of architectural design and composition. The most brilliant period in the history of any style—the period of its full development—presents the most typical

building and structures for analysis, comparative study and research. For in these typical buildings of the best period all the then known laws and principles of architectural design and composition are more or less exemplified. In the analysis of all buildings of a later age, care must be taken to discern what influences of a preceding style have been most potent.

15.—Comparative Study of the Great Styles enables us to discern the common instincts at work in their formation, but with different results from hereditary influences or environment.

Thus, the lotus, first blooming in the spring along the banks of the Nile, becomes the sacred flower of the Egyptians and the emblem of the soul's return to earth after the winter of death. The fleur-de-lis (lily) becomes the Easter flower of Christendom and an emblem of the soul's purity and immortality. Again, the square and rectangle are the invariable ground plans of Egypt's pyramids and temples; the rectangle of the Greek temple containing the sacred cella. The Greek cross is the ground plan of the Greek churches of the East in the Byzantine style, and the Latin cross of the churches of Western Europe in the later Romanesque and Gothic styles. The early Romanesque churches were on the plan of the Roman basilica, and the semicircular or apsidal end of the basilica has been added to the eastern end of the Gothic church. The pyramidal form is distinctly characteristic of the Egyptian, the low triangular pediment of the Greek style, the circular dome of the Byzantine, and the steep roof and tall spire of the Gothic. The equilateral triangle to the Egyptians was an emblem of entirety, the source of all things, and the same figure is full of significance in the Christian symbolism of the Gothic style. And so there are sacred numbers, sacred geometric figures, sacred plants and animals, which have been introduced as ornaments—some imitatively and others conventionally, which have received the stamp of approval of the priesthood and have so become fixed forms in symbolic ornament. Again, it is instructive to study how the great architects of the world have overcome similar obstacles by almost wholly different methods of construction.

PART II.

Ancient and Classical Architecture.

SECTION I.—EGYPTIAN ARCHITECTURE.

I.—Historical Outline of its Development.

1.—Pyramid Age. (About 3900–2570 B.C.) Period of Inception.—Egyptian religion and culture probably took rise in the district of Meroe, in the interior of Africa. It followed the course of the Nile and apparently centered about Thebes, Memphis and Alexandria at different periods. In this age it is about Memphis.

The *Pyramids* face north, and all have the entrance on that side. They have a square base and equilateral triangles for the sides. The entrance passage leads down thence up to a small chamber, probably intended as the tomb for the king who had it constructed. The three great pyramids are at Gizeh. The largest of these, that of Cheops, is 764 ft. on a side of the base and 480 ft. high. The courses are from 2 to 5 ft. thick, of great limestone blocks; passages are granite-lined. There were probably 100 pyramids in all, but their construction ended in Lower Egypt at a very early date, with the old dynasty of Memphis. Situated on the west bank of the Nile, the region of the setting sun, and each group of pyramids the centre of a necropolis, and being built for great duration, we are led to believe that the early Egyptians always associated them with death and eternity.

The *Tombs* surrounding the pyramids were of similar form, but often truncated. The use of the lintel and of the wall post point to a possible wood derivation. The decorations (conventional) on the walls depicted the abodes of the living.

The *Temples* that remain are very few, small, and with scarcely any ornamental feature.

The *Sphinx*, near the second pyramid, is still the riddle of the world. It seems intended to symbolize the strength of an animal combined with the intellect of man, as it has a human head and body of a lion.

2.—First Theban Kingdom. (About 2570–2340 B.C.). Period of Growth.—The old Memphite pyramid-building kingdom has passed away

and given place to the warlike idolatrous race of Theban kings. They were superseded in Lower Egypt by the Hyksos, or Shepherd kings, and finally completely overthrown by them. (About 2340–1830 B. C.). This period is remarkable for the proto-Greek forms in the tombs of Beni Hassan.

Obelisks now take the place of the pyramids and are all on the eastern side of the Nile, toward the rising sun. The earliest and finest is at Heliopolis, and is a splendid block of red granite, 67 ft. 4 in. high. They are covered with hieroglyphics.

The *Labyrinth* is one of the most remarkable and most mysterious monuments of Egypt. It is supposed that Mœris built it as a sepulchre for himself. It has winding and bewildering passages, with many small chambers.

The *Tombs* of this period are most interesting. They are on the eastern side of the Nile. The tombs of Beni Hassan, in Middle Egypt, have pillars like the Greek Doric, with a square abacus showing a possible derivation from brick architecture. There is also a Reed pillar in imitation of four reeds or lotus-stalks bound together near the top and bulging above the band so as to form a bud-shaped capital. This form of support was probably first used in light wooden construction, and in supporting the roof of slight slope for the dry climate of Egypt. The square pier, characteristic of the pyramid-building age, is also used at Beni Hassan, and is adorned on its face with a lotus flower and stems. Where wood was used the masses were probably cut away at a later date, leaving only the stems. This again came to be reproduced in stone, itself after a while losing almost all trace of the original. Such is the probable origin of the bud and the lotus capitals of the Egyptian style. The pillars at Beni Hassan rested upon large circular plinths, and supported stone lintels.

3.—Great Theban (Pharaonic) Kingdom. (About 1830–1312 B.C.). Period of Full Development.—The pyramid is no longer the royal sepulchre, but is replaced by long gloomy corridors cut in the rock. Instead of the precise orientation of the old kingdom, the buildings are placed anywhere, facing in any direction, and often disregard the laws of symmetry. The most complete temples are at Thebes—the "hundred pyloned city of Thebes." From the expulsion of the Shepherds to the Exodus of the Jews Egypt rose in greatness and splendor, and reached her highest artistic development. The people were under the influence of the most degrading superstition, with no political freedom.

The *Temples* were of two classes, those erected on the surface of the ground and those cut out of the solid rock. The best examples of the former are Karnac and Luxor at Thebes; the rock-cut temples at Ipsamboul of the latter. All the excavations in Upper Egypt (Nubia) are temples. The Nubian rock-cut temples, like rock-cut examples all over the world, are copies of structural buildings, only modified somewhat to meet the exigencies of the situation. There can be no great development inside, as light and air can only come from the one opening of the doorway.

The *Tombs* are all excavated out of the solid rock in Egypt proper. The royal tomb began so soon as the king ascended the throne and ceased at his death, so that these rock-cut tombs show their work in all stages of progress. Their walls are covered with paintings and hieroglyphics of singular interest and beauty, depicting the abodes of the living and the journeys of the dead.

The *Obelisks* continued to be erected and are seen in front of almost all the old temples of the country.

4.—Later Theban Kingdom. (About 1312–525 B.C.). Period of Decline.—From the Exodus of the Jews, Egypt sank through a long period of decay till the Persian invasion under Cambyses, 525 B.C. The decline continued during the Greek and Roman occupation, with but few exceptions. Edfou and Philæ are the great temples of this period. Much irregularity distinguishes all the later Egyptian work from that of the rigid and proportion-loving builders of Memphis.

II.—Analysis of the Egyptian Style.

1.—Characteristics and Elements of Construction.

1st.—*Site.*—The great monuments are along the Nile; some near vast natural beds of stone, in other cases immense blocks were transported hundreds of miles.

2d.—*Planning.*—Square and rectangular forms throughout; only one opening to pyramids, tombs, rock-cut tombs and labyrinth, skillfully concealed by great blocks of stone. Egyptian symbolism pervades every structural arrangement and form. Successive apartments diminish in size from front to rear, and the several parts and details become smaller.

Typical Egyptian Temple.—(1) Rectangular temple building itself; (2) closed court surrounding actual temple; (3) stupendous entrance-gate of peculiar shape, called a pylon. Avenue to pylon leads through long rows of colossal sphinxes and smaller pylon-shaped gates. The pylon consists of two high pyramidal-shaped towers, with entrance-gate between them. Colossal statue in sitting posture and obelisk on each side of entrance. Temple court within has no roof, but rows of columns on two or four sides, supporting roof over side aisles. Next is the hypostyle hall, whose roof is supported by many columns. Space between columns is about 1½ diameter of shaft. A smaller chamber succeeds, sometimes equally rich in columns. Then one or two vestibules, without columns, lead to small sanctuary, with only one door. In almost all cases the columns are interior.

3d.—*Material.*—Sandstone in earliest structures and at Thebes; granite in later work and in Lower Egypt; red granite in obelisks, colossal statues and temple columns.

4th.—*Structural Elements.*—Horizontal or lintel system; external walls on a "batter;" internal walls perpendicular; flat stone roofs. Shafts, cylindrical, sometimes tapering, rest on circular plinths. The abacus is a square block of stone, width of shaft and narrower than capital; upon the abacus rest the ends of the stone lintels, then the cross pieces and roof slabs. Mouldings are rare; the only one is the hollow or concave moulding (cavetto), combined with a half-round fillet, seen as the cornice moulding. Window openings rarely used. Doorways large and sometimes with sloping jambs.

5th.—*Stability* ensured by the use of a superabundance of material. The small abacus a very essential feature for the effect of stability.

6th.—*Durability* was the chief object of all early Egyptian work and one object of later.

7th.—*Sanitary.*—Light and air entered through door and open courts. Two middle rows of columns of hypostyle hall, higher than the side columns, admitting light and air between the two roofs.

8th.—*Execution.*—Nothing more mechanically perfect has ever been built since the pyramids. Besides skillful and careful masonry, they show knowledge and application of its principles. Later periods, though showing less skillful execution, have developed higher decorative work.

2.—Characteristics of Egyptian Ornament.

1st.—*Kind.*—*a. Constructive.*—Capitals convex or bud-shaped, like closed bud of papyrus (reed) or of lotus; and concave—hollow or bell-shaped, like open lotus flower or spreading palm. Isis-head capitals also seen in some temples, besides bud, lotus and palm capitals.

b. Decorative.—Hollow cornice moulding, ornamented with vertical figures and stripes, the fillet below it with zig-zag of straight lines. The lotus flower served as a type for the forms of capitals and their decoration. Lotus and palm capitals, enriched with scale-like decorations, or leaf-shaped triangles.

2d.—*Forms.—a. Geometric.*—Equilateral triangle, square, circle, zig-zag, waved line, wave-scroll or spiral, straight and curved line, fret forms (labyrinth), for border or surface; star and wheel or rosette forms.

b. Conventional.—All natural forms used in ornament treated in highly conventional manner. Once used in symbolism of temple decoration they became fixed for all time. These forms lack the charm of fanciful development, yet are the earliest examples of conscious conventional adaptation of the forms and details of local natural objects. Such were reed, lotus and palm forms, beetle, asp and many other sacred animals.

3d.—*Classes.—a. Symbolic.*—Literally hieroglyphic style in sentiment and details, derived from priestly symbolism. Applies from decoration of ordinary utensils to palaces, temples and monuments.

Zig-zag and wave-scroll symbolized water in motion—the Nile. Borders.

Lotus, water-lily of the Nile—new birth and future life. Prescribed and conventional forms in almost every kind of decoration, singly or in combination with fret, spiral, wave-scroll or star form.

Papyrus (reed) and *palm*—food, sustenance. Columns and capitals.

Swelling asp—dominion, kingly and distributive power. Simple repetition in wall and frieze decorations.

Cartouche, or shield containing hieroglyphics, with swelling asp on each side. Wall and frieze.

Sphinx, human head and body of lion—intellectual and physical power.

Winged globe—the trinity of powers. The globe—the sun, creative power; the wings on each side—providence or protective power; the swelling asp on each side—kingly or distributive power. Placed over every entrance on hollow cornice.

Winged figures of other kinds often used—vulture, hawk, cat, dog, beetle, snake, asp. Symbolized mental and physical power of different divinities by union of human head with bodies of sacred animals.

b. Æsthetic ornament not in the Egyptian style.

4th.—*Material and its Treatment.*—Large figure sculpture on walls, in depressed relief, with raised surfaces sloping toward sunken outline. Hieroglyphics and other figures on walls and obelisks deeply incised. Some decorations simply painted on flat or raised surfaces. A few examples of free chiselling of stone in relief. No decorative work applied to walls, pillars, piers, cornices, etc., till stone blocks were in place.

Objects of daily use, embellished with decorative features, similar to those used in architecture. Ceramic wares, vases of stone and earthenware; sarcophagi; rings, idols, amulets, weapons, furniture, and precious objects in ivory, silver and gold.

5th.—*Color* much used and added a charm to all their decoration. White, black and deeper shades of green, with primary colors—red, yellow and blue; used only as pigments.

6th.—*Sculpture and Painting* freely used, but conventional. Egyptian ornament admits of no images or pictures of objects. Walls, cornices, doorways, columns and piers covered with colored sculpture paintings. Human figure, sacred and winged animals, and sphinx characteristic forms. Scenes on wall paintings in profile—mere diagrams in elevation, treated with much vigor and rigidity of line; subjects dealt with are the lives of

kings, their victories, offerings and other ceremonials, and the various relations of popular life with respect to religion, agriculture and handicrafts.

3.—Characteristics of Egyptian Composition.

1st.—*Principality* scarcely recognizable. A certain duality and balance in almost all Egyptian work—two pylons, two obelisks, two colossal statues at temple entrance.

2d.—*Size*, mass or vastness of proportion is seen more than in any other style. Most noticeable in the pyramids, it becomes less marked with each advancing period.

3d.—*Proportion* well thought out in each period, but of differing character according to type of structure. The pyramids and obelisks almost perfect for their kind. The obelisk seems transitional from pyramidal form to square pier, thence clustered shaft of reeds, and finally the round shaft of temple architecture. Egyptian columns: reed shaft, about 3¼ diameters, but capital 1; lotus capital, 1 diameter, shaft about 4½. Early columns about 4 and later ones 6 diameters in total height—sometimes 65 feet.

4th.—*Harmony* not well developed.

5th.—*Symmetry* most fully developed. Some later temples do not show careful balancing of distances and squaring of corners that the pyramids maintain.

In construction the plan shows balanced distribution of parts from front to rear. A row of lotus columns on the right in hypostyle hall is set off by a similar row on the left; rows of bud-capitalled columns to left of these balance rows of similar columns to right of those. Front elevation shows similar balance, but side elevation shows decreasing heights from front to rear.

In decoration greatest symmetry is observed, of vertical bands, of horizontal bands, of conventional plant or animal forms, of conventional wall paintings and hieroglyphics. By mere symmetrical arrangement incomprehensible hieroglyphics become pleasing features. This simple symmetrical arrangement seems the extent of their scheming and designing, a simple progression or repetition in horizontal lines or diaper (row upon row, horizontally or diagonally).

6th.—*Repetition* of simple forms, structural and ornamental, simplest and most effective for their peculiar symbolism. Alternation is rarely seen in structural forms, but often in ornamental details, in which there is also great variety. Two columns, alike in every respect, with complete decorations, were never placed together in the same colonnade or row of columns, but sometimes used as a pair of opposites.

7th.—*Contrast* obtained occasionally, whether of masses or details, of form or color, or of direction simply.

8th.—*Fitness* throughout, whether in tombs or temples, utensils or palaces—all seem well adapted to serve their purpose, their day and age.

9th.—*Associations* are faithful and characteristic in almost every period. Assyrian, Greek, and finally Roman influences may be noted in the period of decline.

10th.—The *style* of typical buildings of each period well marked—pyramids and obelisks, temples and palaces. In decoration it shows complete adaptation of its own natural productions—a systematic, conventional treatment of its local, natural types.

III.—Comparative Study of the Egyptian Style.

1.—In Relation to Earlier Styles.—The Egyptian style, at its full development, is purely an outgrowth of the soil, of the early life and manners of the people of the Nile. No trace of any previous architecture of another country. Its great antiquity, its full development before other great styles had birth, its distinctive features as a child of the Nile, all make the Egyptian style the oldest and purest style of the world. It therefore deserves the fullest study and analysis if we would understand the later great styles.

2.—In Relation to Its Own Development.—In construction, we note survival of pyramidal form, obelisk and sphinx, lintel system and one-entrance feature; the square pier and reed pillar of Beni-Hassan are prototypes for the temple architects. In ornament, the bud capital on reed pillar and expanding lotus-flower decoration at top of square pier of Beni-Hassan, develop into beautiful bud and lotus capitals; palm and Isis-head capitals added later. The hieroglyphic and symbolic nature of the ornament develops into most rigid conventionalism. Profusion of decorated surfaces, but little development in use of purely constructive ornament. In composition, early attention paid to proportion combined with size or mass; later on, more to symmetry, repetition and contrast.

3.—In Relation to Later Styles.—Many forms of lotus ornament developed in the Assyrio-Persian style, but with variations due to changed environment—less symbolism and more æstheticism. From Beni-Hassan, the simple fluted shaft and bud (cushion-shaped) capital, with square abacus and lintel construction are prototypes of Greek Doric. The cluster of the lotus in form of its leaf is a beautiful compound example, a symmetrical arrangement of the flower in circular, or rather oval series. It is the unit or motive of the ordinary horizontal series of Egyptian ornament. This anticipates the Greek anthemion.

Lotus clusters and lotus spirals were more used in Assyrio-Persian ornament than Egyptian, and appear to have developed certain proto-Ionic forms. Whether Greek Ionic forms developed from Assyrio-Persian through Asia Minor, or more directly from Egypt, certain it is that the lotus forms and spirals of Egypt exercised much influence.

The lotus capital appears a fitting prototype of the beautiful Greek Corinthian, or acanthus capital.

Egyptian decoration was not without an influence upon all people connected with Egypt. It shows the first systematic efforts in design in the history of the world. Not a few details are popular ornaments to-day.

SECTION II.—ARCHITECTURE OF ASSYRIA AND PERSIA.

I.—Historical Outline of its Development.

Three styles of architecture, the development of three distinct races—the Chaldean, Assyrian, Persian. None of these styles were really distinct and pure. Each was great in the order given, and dominant in its period of full development, that here considered. Each style was more or less impregnated with the influences and characteristics of the other two.

1.—Chaldean Period.—Ancient Babylonian. (About 2235–1520 B.C.)—Most probably founded by Nimrod, near mouth of Euphrates.

Temples, tombs, private dwellings—all typical of Turanian race. Imperfect knowledge of these structures, because built of crude, sun-dried, or partially burnt bricks; when good bricks were used they have been quarried and used by a later age.

Birs Nimroud, near Babylon, the typical temple. Seven stories, all square in plan, dedicated to the seven planets (as then considered); top story contained the cella or sanctuary. Each story, reached by outside stairs, being smaller than the one below it, gives a stepped outline, or pyramidal form. Temple at Mugheyr has terrace-like lower story—sloping external walls. A later age built the so-called tomb of Cyrus, a stone copy of early temples. Decorations chiefly in elaborately colored plaster work on walls.

2.—Assyrian and Second Chaldean. (About 1290–538 B.C.).—An invasion from the west (Egypt?) about 1520 B.C., depressed first Chaldean, and enabled the Assyrians to rise and found the kingdom of Nineveh, about 1273 B.C. These great people of Asia for about six centuries, built in the latter half, the palaces recently disinterred. They gave way to the second Chaldean (Babylonian) kings, and these, in turn, to the Persians, under Cyrus, 538 B.C., at the destruction of Babylon. Architecture chiefly palatial, no tombs, few temples, characteristic of a Semitic race.

Northwest Palace at Nimroud, almost square in plan, built upon terrace, with entrance on north, adorned with winged bulls. Throne at upper end of great hall; several side apartments around inner court. All apartments lined with sculptured slabs.

Khorsabad Palace, about fifteen miles from Nineveh, built upon great mound. Corners point north and south, or east and west. Has vaulted passages and drains and arched gateways. Central portal flanked by great human-headed bulls, and, with two other portals, gives entrance to great outer court. The great central court is square. All principal parts of palace revêted with sculptured alabaster slabs, representing wars or peaceful games of King Sargon (721 B.C.), showing his magnificence and expressing his religious feelings. Above slabs the brick wall was decorated with conventional designs, painted on stucco. Chambers and halls very narrow in proportion to length. Almost flat roofs supported by immense pillars. Lavish use of color and carved ornaments in bas-relief, some showing certain proto-Ionic forms.

3.—Persian. (About 538–333 B.C.)—.Architecture palatial, with rock-cut tombs and small temples, showing strong Turanian tendencies. This style, essentially copied from preceding, best developed at Persepolis, in great palaces of Xerxes and Darius. While at Nineveh structural parts —pillars, roofs, etc., were of wood, at Persepolis stone was used in repeating wooden forms of the Assyrian.

Persepolis.—Ruins show terraced substructure of most massive Cyclopean masonry. Great flights of steps led to palace halls. Central halls square in plan, and studded with pillars, placed equidistant. Human-headed winged bull on each side of first public entrance. The same king modelled his tomb after his palace, and the remains of the tombs enable us to judge of palace construction. Palace walls covered with sculptures, and inscriptions in Persian cuneiform.

II.—Analysis of the Assyrio-Persian Styles.

1.—Characteristics and Elements of Construction.

1st.—*Site.*—Along Euphrates and Tigris, at Babylon and Nineveh, and at Persepolis.

2d.—*Planning.*—Chiefly square in plan, on great mounds or terraces—pyramidal-shaped; height obtained by story above story; access by long flights of steps; later plans show great open courts and many-pillared halls and porticoes.

3d.—*Material.*—Brick and wood, whose forms were later copied in substantial stone construction in the rocky country of Persia. Materials chiefly used found in vicinity.

4th.—*Structural Elements.*—Horizontal or lintel system; occasional use of round and pointed arch for doorways, vaulted ceilings and drains. Shafts, cylindrical or tapering, generally fluted, rest upon plain cylindrical or inverted calyx base; abacus quite small and square. Cornice moulding, hollow and projecting, like the Egyptian. Doors large, windows rarely used, roof slightly sloping.

5th.—*Stability.*—All structures quite massive and substantial, though high, slender, fluted shafts, light roofs and porticoes took away any idea of extreme solidity.

6th.—*Durability* only ensured during the Persian period, massive stone structures. Assyrian brick and wood construction has left few remains.

7th.—*Sanitary.*—Light and air admitted by open courts, porticoes, and raised central roofs as in the Egyptian style. Great vaulted drains under palaces. Some palaces, as Khorsabad, almost entirely surrounded by natural or artificial waterways.

8th.—*Execution.*—Skillful masonry in terrace walls, drains, arched construction, etc.

2.—Characteristics of Assyrio-Persian Ornament.

1st.—*Kind.—a. Constructive.*—Capitals quite different from any preceding. Those at Persepolis of two kinds: the first formed by half trunks of two horses or other animals, facing outward, and on back of which the wooden entablature rested; others show upright calyx upon inverted one, above which are volutes placed vertically.

b. Decorative.—The cornices, simple in section, painted and surmounted by palmetto-shaped tiles. Interior walls covered with bas-reliefs or paintings on stucco or plaster. Figures and animal forms (like the Assyrian sculptures) fantastically mingled with foliage and inscriptions. Hollow, Egyptian-like cornice showed several rows of leaves, in strictly conventional style of sculpture, filling the broad hollows.

2d.—*Forms.—a. Geometric.* Circle, star, patera (rosette) forms, zig-zag, guilloche, scrolls; rosettes enclosed in squares as in diaper work. A wall at Wurka, panelled and moulded vertically, shows mosaic of small colored bricks, arranged in equilateral triangle and diamond-shaped patterns, horizontal, zig-zag and vertical spirals.

b. Conventional. Natural forms strictly conventional as applied in ornament, but more freedom of treatment than in Egyptian style. Many varieties of lotus and bud in horizontal borders. Fir cone and lotus often combined. Palm tree is seen in many forms. Winged bulls, lions, horses and griffin, singly or combined, with vegetable forms and human-headed figures.

3d.—*Classes.—a. Symbolic.* Cuneiform inscriptions, sacred winged animals, conventional forms of sacred palm tree.

b. Æsthetic ornamentation appears in a small degree. The Assyrian and Persian loved sumptuous display, and richness of effect rather than rigidly symbolic treatment.

4th.—*Material and its Treatment.*—Plaster work, mosaics, enamel, gem-cutting, weaving, working of ivory, glass, gold and other metals show that Assyrian art achieved great excellence. Recent excavations attest this in architectural decorative art, vessels of all sorts, ornaments, and objects of daily use.

External walls faced with painted and glazed tiles, and slabs of stone; internal walls show beautiful decorated alabaster slabs and stucco work above them. Almost all carving, sculpture and applied ornament in bas-relief.

5th.—*Color*, either in form of pigment or of colored material, added much to richness of decoration. Natural or artificially colored materials —tiles, slabs, mosaics, etc., produced rich effects of color by their arrangement on floors, wall surfaces, cornice mouldings, etc. Pigment colors and those artificially burnt in, principally primary—red, yellow, blue.

6th.—*Sculpture and Painting* still conventional, but far more spirited than Egyptian. Oriental love of splendor developed a feeling for rich decoration, which extended to all kinds of art workmanship. Wall decorations show religious ceremonials, scenes of war and peace.

3.—Characteristics of Assyrio-Persian Composition.

1st.—*Principality* only in part. Subordination in plan, and in decorative features. Co-ordination, or equality of parts, structural or ornamental, appears occasionally.

2d.—*Size* and massiveness of proportion still a main feature. Great pyramidal substructure, long flights of steps, vast Cyclopean walls, great halls and courts; colossal winged animals guarding entrance of great arched doorways and of halls. Later forms more light, slender and delicate.

3d.—*Proportion* not well developed, but adapted to kind of structures, material and climate. Covered halls very high, long and narrow, possibly by reason of difficulty of vaulting with small material or even bricks. In some instances the walls are so thick that they cover as much ground as the rooms, keeping out the heat. Great high galleries formed light and airy compartments for morning and evening. Columns with calyx-voluted capitals have height of base about 1 diameter, shaft, 6; upright and inverted calyx capital, 1½; vertical voluted capital above this also 1½. Columns with horse capitals have height of base about 1 diameter; shaft, 9½; double half-horse capital, 1½. Total height, 60 to 65 ft.

4th.—*Harmony* partially developed, but more in ornamental details than structural features.

5th.—*Symmetry* quite fully understood and developed. Balance of structural and ornamental features somewhat like Egyptian style.

6th.—*Repetition* in borders and diaper work, of geometric or conventional forms, arranged upon a geometric basis. Alternation of series of straight or circular borders or bands of decoration. Inversion of repeated or alternated forms. Radiation or circular repetition often used in rosettes, squares, shields, patera. Orderly repetition of structural features.

7th.—*Contrast* of form quite marked—conventional, animal and floral designs, geometric forms and structural parts.

8th.—*Fitness* clearly shown in adaptation of means to end—massive and elevated structures for grandeur and comfort; gorgeous use of color in conventional ornament in keeping with Eastern love of splendor.

9th.—*Associations* generally and peculiarly Asiatic, rather than particularly local. Assyrio-Persian art and architecture show on every hand mutual contact and close relations of contiguous countries and races, in politics and religion, commerce and ordinary intercourse.

10th.—*Style* of the Assyrian and Persian buildings is not so well marked nor characteristic as the Egyptian.

III.—Comparative Study of the Assyrio-Persian Style.

1.—In Relation to Earlier Styles.—Throughout preceding pages reference has been made to the influences of Egyptian art. It must be borne in mind that these were most marked after the Persian invasion of Egypt, under Cambyses, who, we are told, carried a colony of Egyptian artists back to Persia. Remains of their influences are seen in the whole basin of the Euphrates, from Nineveh to Persepolis.

Egyptian style shows grandeur of proportion, simplicity of details, costliness and splendor of material—precious stones, ivory, gold, silver, and color, as the chief art characteristics. Assyrio-Persian style also possesses this prevailing characteristic of sumptuousness. The latter took nature as a guide, and did not follow a set of rigidly conventional and traditional forms. This is an important step in advance, and along lines which the Greeks developed to such refinement—a refinement of beauty of form almost foreign to Asiatic and Egyptian art. Not being so fettered as Egyptian, the Assyrio-Persian art developed more spirit, variety and action, but lost the grand simplicity of Egyptian by petty details and trivial ornaments. Lotus forms, winged figures and animals have an Egyptian character, but less conventional.

There are really no distinctively new forms in the Assyrio-Persian. Some forms have been further developed than in Egypt, the rosette, star-forms and patera; guilloche (double-waved line); compound lotus cluster, similar to the palm cluster, and both good prototypes of the Greek anthemion; fir cone may be shown to be development of lotus bud.

2d.—In Relation to its own Development.—Notwithstanding later Egyptian influences, there is a certain survival of early and more purely Asiatic influences; construction in stories; decoration of tombs showing altars, temples and religious ceremonials; use of animals for bases and capitals; terraced foundation and great flights of steps; light porticoes and simpler and more regular ground plan.

3d.—In Relation to Later Styles.—It is not difficult to see, in the tomb of Cyrus, a fitting prototype of the Greek temple pedimental roof and flights of steps. Also, use of palmette tiles on cornice will be noticed in Greek temple, and Assyrian palmette tile-form is much like Greek antefix, used for same purpose. Wall sculptures and decorations, representing altars and temples, with columns, palm trees, etc., show voluted capitals almost identical to Greek-Ionic, and some almost like the Corinthian. Whatever may be the origin of the beautiful Greek-Ionic voluted capital, the Assyrio-Persian style shows a prototype.

SECTION III.—GREEK ARCHITECTURE.

I.—Historical Outline of its Development.

1.—Period of Inception. (About 1200—Solon, 600 B.C.)

The *Pelasgi* spread from Asia Minor and its coasts to the Hellas, the islands of the archipelago, and were first known occupants of Greece, being there called Ionians. Pelasgic colonies settled in Sicily and Italy (Etruria) and were known as Etruscans. The Pelasgi were a tomb-building and art-loving race, whose architectural forms show certain influences of Asiatic art, notably of Persepolis. Few remains: tombs, circular walls round towns, palaces; simple and massive; Cyclopean masonry—great polygonal blocks of stone accurately fitted, sometimes coursed, no mortar used.

The *Dorians*, coming from northern and settling in southern Greece, infused a new element. Their simple, severe and massive architectural forms show Egyptian influences. Art was unknown in the Dorian city of Sparta, but flourished in the Ionian city of Athens, in Attica. The common sense, matter-of-fact Doric combined with the æsthetic Ionic produced the most brilliant and glorious development of art and architecture the world has yet seen. Like other Aryan races the Greeks never were tomb-builders. Their chief remains are temples, upon which were bestowed the greatest care and highest art.

2.—Period of Growth. (Solon—Pericles, 600–440 B.C.)

Doric Age—first historic age of Greek art. Its terra-cotta vases show all the characteristic ornaments of Greek style of decoration, the same ornaments which, modified in treatment, distinguished the architecture of the time. Ionic forms contended with Doric, sometimes in the same spot, but were kept quite pure and distinct. Establishment and development of Doric order; as, temple of Olympic Zeus, Athens; of Apollo, at Delphi; and in islands and colonies. Ionic order introduced and partly developed; best temples in Asia Minor, as temple of Diana, at Ephesus.

3.—Period of Full Development. (Pericles—Alexander the Great, 440–336 B.C.)—Doric order, freed of its former massiveness, showed most graceful proportions; Ionic order, no longer confined to the Hellas and Asia Minor, displayed richer and higher phases of beauty joined with Doric severity; Corinthian order occasionally used for smaller monuments.

Art and architecture attained its highest development and most beautified perfection at Athens, on and around the Acropolis. Here was the Parthenon, Doric order, 438 B.C.; the Erectheium, Ionic, 409 B.C.; the Propylæa, an entrance whose exterior resembled the Greek temple; the temple of Nyka Apteros and statue of Minerva.

Other structures: stadia, for gymnastic exercises; theatres; tombs, simple and plain, sometimes rock-cut with decorated facade; propylæum, a temple-like entrance gateway to the temple. Of the monuments for victorious choragus in musical competitions, the most noted is that of Lysicrates, Corinthian order, 335 B.C., at Athens.

4. Period of Decline. (Alexander the Great—Roman Subjugation, 336–145 B.C.) Alexander desired to advance Greek art; Greek culture was widespread; new cities were founded; great designs were carried out with splendor and luxury, little in keeping with preceding age. No important buildings in Greece. Doric order fell into disuse, Ionic little used, Corinthian almost exclusively used.

II.—Analysis of the Greek Style.

1.—Characteristics and Elements of Construction.

1st.—*Site* chosen to show building to best advantage, and on elevated spots like Acropolis. Theatres sometimes located by side of rising ground, with background of natural scenery.

2d.—*Planning.*—Temples rectangular in ground plan; a few circular. Early temples have ends of sidewalls projecting in front, forming pilaster-like piers, between which two columns are placed. Next is prostyle arrangement—four columns in front and sidewalls ending in simple pilasters. Another form shows this prostyle in rear as well as front. The peristyle temple is surrounded by columns, as a single or a double colonnade, with six or eight-column porticoes in front and rear; this arrangement, with the six-column, or hexastyle portico, is most prevalent. Others have single or double colonnades with eight or ten-column porticoes. The cella, often a small complete inner temple itself, inclosed by columns. Greek style shows external and internal colonnades, but external seem more used. Door at both ends, windows rarely used.

Parthenon, surrounded by single colonnade, Doric; 8 columns in front, 17 in side view. Temple of Diana, surrounded by double colonnade, Ionic; 8 columns in front, 20 in side view. Erectheium, a group of three temples; north portico, 4 Ionic columns; east portico, 6 on different level; south caryatide porch of different style and height. Choragic monument of Lysicrates, circular in plan, upon square base, entablature supported by 6 Corinthian pilaster-columns, and surmounted by acanthus-scroll finial. Stadia, oblong in plan; theatres, semi-circular.

3d.—*Material* of primary importance in the development of an architectural style, practically determines its forms, having as great an influence as nationality and æsthetics. Purest and best white marble in Parthenon. The use of beautiful close-grained marble no doubt exercised great influence on development of Greek art. Stone construction throughout this style giving distinct character to all exteriors. Interiors sometimes of wood; roof of wood and often of stone.

4th.—*Structural Elements.*—Horizontal or lintel system, with columnar orders—Doric, Ionic, Corinthian, in which the column is a distinguishing feature.

An ORDER consists of: (1) Pedestal, or foundation block or course. (2) Column, with a base or foot, a shaft or body, and a capital or head. (3) Entablature; with architrave, the beams or lintels supported by the columns; the frieze or cross beams; and cornice—exterior of rafters covered by moldings. (4) Pediment or gable, surmounted by corona-molding.

Greek orders have no pedestal, but rest upon the stone steps (3), or plinth.

DORIC ORDER.—No base; shaft tapering with slight swelling near middle, called entasis; 20 flutings from top to bottom with no spacing between them; necking near top under a convex, cushion-shaped capital; square abacus. Architrave, a smooth rectangular block separated from frieze by projecting ledge or fillet. Frieze regularly divided by sets of prism-shaped grooves (triglyphs), into square compartments called metopes. The triglyphs are regarded as supports of the cornice; somewhat resemble earlier

wood-construction. Six small conical drops (guttæ) hang from the fillet beneath each triglyph. Three rows of six small blocks (mutules) are above each triglyph and metope, on under surface of projecting corona—in slanting position. Pediment, triangular, with broad, flat fillet on base and ogee (cyma) molding on sides.

Ionic Order.—Base, hollow channel (scotia) below a projecting cushion (torus) molding. Attic base more usual form—two large beads (tori) separated by hollow (scotia) molding. Shaft diminishes less than Doric, with gentler swelling (entasis); twenty-four flutings, terminated at top and bottom by a curve, and separated from each other by narrow shoulder or fillet; flutings narrower and deeper than Doric. Convex, cushion-shaped capital, with projecting extremities curled into spirals to form volutes; in angle-columns these volutes often constructed to meet diagonally, volutes closely attached to sides of capital and bend over and downward with a free sweep; sometimes they consist of two fluted members. Abacus, square-shaped, often with echinus molding.

Architrave formed by projecting ledges or facia (3), surmounted by small bead (astragal), echinus, and projecting hollow (cavetto) moldings. Frieze, plain or ornamented, surmounted by astragal and echinus moldings. Corona is reached by several richly molded gradations, among them the typical dentil band or bed-molding. Triangular pediment surrounded by cyma molding on corona.

Corinthian Order.—Base and shaft similar to Ionic. Capital formed by outspreading graceful volutes, which, with smaller and inward volutes, are developed like a stem from the flower, cup-shaped capital. Abacus square-shaped, with hollow curved sides. Architrave similar to Ionic; frieze, plain or ornamented. Brackets (modillions) support cornice, and may be used in conjunction with the Ionic dentil band. Spaces on under side of cornice, between modillions, filled with panels in sunken frames, and rosettes.

Doors and windows sometimes narrowed toward top, composed of few members; lintel occasionally surmounted by ornamented cornice.

5th.—*Stability.*—The tapering shaft serves to give idea of greater strength, and the entasis an elastic and life-like appearance to this support; entasis usually a hyperbolic curve. Greek columns are typical ones of relation of supporting to supported body, especially of the capitals—Doric cushion-shaped echinus and its necking, as well as Ionic or Corinthian volutes, seem most appropriate as suggesting an elastic cushion. Plant-like fluted shaft, with its entasis, expresses inherent strength. Absence of base in Doric, and cushion-shaped and spreading Attic bases of Ionic and Corinthian are equally appropriate as expressing stability. For this, as well as for optical reasons, all columns slope slightly inward, and the four architraves of the Parthenon rise toward centre in a very gentle parabolic or hyperbolic curve.

6th.—*Durability* insured by accurate scientific construction and use of selected stone.

7th.—*Sanitary.*—Cella or naos, and interior in general, lighted from above by longitudinal openings in roof between centre and side aisles. Windows rarely used.

8th.—*Execution* was worthy of the Greeks; the material used, their love of moderation and precision contributed alike to this end.

3.—Characteristics of Greek Decoration.

1st.—*Kind.—a. Constructive.*—Projecting ends of sidewalls (antæ) and pilasters were ornamented much like the columns used in same building, but Ionic volutes usually omitted. Dentil course possibly derived from rafter ends in wood construction. Scroll or volute-shaped brackets (modillions) fewer in number than dentils, but richer, more ornamental and projecting. The structural requirements in all capitals, to change from circular shaft to square-shaped abacus, occur at once in Doric cushion-shaped capital, but in Ionic are modified by the volutes, and in Corinthian by the cup or calyx-shaped capital beneath the light-spreading volutes. Constructive meaning of moldings expressed by their form and decoration.

a. Decorative.—Doric. Capital invariably decorated (painted) with egg-and-dart (echinus) ornament; this is such a dominant ornament (motive) of the period that Doric order is sometimes called the Echinus order. Metopes, open at first, were closed by slabs ornamented with figures in relief. Corona in front often ornamented with leaf pattern, anthemion, or palmette; a similar ornament is usually carried around pediment on ogee (cyma) molding, with projecting lions' heads at ends.

Over the latter are placed foliated ornament, richly decorated figures and griffins, but generally palmette forms, which, when so used, are called acroteria. On the summit of pediment is placed a facade tile (antefix), usually palmette. Pediment is often sculptured with figures in relief.

Ionic.—Volutes added to Doric echinus capital. Above is the echinus-molded abacus. Below are three moldings—double wave-line interlace (guilloche), large echinus and small astragal; then a broad belt of running flower ornament (anthemion)—palmette and lily forms alternating; and a small astragal molding joining the shaft. Some Ionic capitals have only the large echinus and small astragal moldings under the volutes. Frieze, plain or ornamented in relief with scroll-work, religious vessels, etc. Echinus and astragal moldings are placed between architrave and frieze, also just below and above the typical dentil band of the cornice. Corona of cornice and of pediment is a large cyma molding, richly decorated with anthemion.

Corinthian.—Cup, bell, or calyx-shaped capital, decorated with acanthus buds, leaves and stalks, below light-spreading spirals—inward and outward; simple palmette-form placed above small inward spirals. But the acanthus is such a principal ornament (motive) of this order, that it is sometimes called the Acanthus order. The details of the order admit of great variety, especially in manner of shaping the capital. Frieze similar to Ionic; modillions richly decorated with acanthus leaves, sprays, and rosettes in eyes of volutes or scrolls. Panels between modillions decorated with acanthus rosettes in squares, with echinus borders. Large cyma molding of corona, plain or decorated, similar to Ionic.

Moldings were much used by the Greeks to aid horizontal features so prominent in their style. They were decorated by painted or carved ornament in such a way as to express the constructive meaning of their form; that is, profile of molding determined choice and arrangement of its particular decorative feature. Cross-sections, or profiles of Greek moldings, are generally curves of ellipse, parabola, or hyperbola.

Fillet, rectangular profile—plain, used between curved moldings.

Tenia, large fillet—plain or painted with fret, on Doric abacus and corona.

Astragal, small bead of semi-circular profile—alternation of oval and two disks—a bead between other moldings, and below echinus in Ionic and Corinthian architrave and cornice and Ionic capital, sometimes a bead between capital and shaft of Ionic and Corinthian.

Torus, large bead—plain or with guilloche or garland—on column base, especially Attic base.

Scotia, hollow—plain or painted—a base molding (Attic).

Cavetto, projecting hollow—plain or painted—a crowning molding of cornice.

Echinus, convex, like Doric capital—egg-and-dart—on Ionic and Corinthian architrave and cornice, on Ionic capital and sometimes abacus.

Cyma, ogee shape. Cyma-recta, concave above and convex below, running flower ornament (anthemion)—on upper division, or corona molding of Ionic and Corinthian cornice. Cyma-reversa, convex above and concave below—plain or leaf-and-dart—on corona of Doric pediment, under Ionic abacus when square, and sometimes Corinthian cornice.

2d.—*Forms.—a. Geometric.*—DORIC: fret or labyrinth, zigzag, wave or Vitruvian scroll; great variety of geometric forms and combinations in diapers and borders; rectilinear forms; curved lines and surfaces rather flat than round—parabolic; guilloche (double wave-line) and astragal rarely used. IONIC AND CORINTHIAN: developed the spiral, guilloche and ordinary wave-line or vine-scroll spiral—a succession of spirals reversed alternately; the guilloche—a curved line plat, supplants the fret—a right line plat; curvilinear forms; curved lines and surfaces very prominent—elliptical and sometimes circular; astragal much used.

b. Conventional.—Extremely rare to find any natural treatment of details. Various kinds of foliage on terra-cotta vases are treated as mere diagrams without reference to any natural representation of light, shade or color. Conventional forms on vases used as decorative features, especially in Doric, where they were painted on the stone—running flower ornament (anthemion), an alternation of palmette and lily form; and egg-and-dart (echinus). Ionic used these and the leaf-and-dart. Richest and most beautiful use of conventional foliage is to be seen in Corinthian—the buds, leaves and stalks of the acanthus spinosus, or narrow prickly acanthus.

3d.—*Classes.—a. Symbolic.*—In Doric period certain emblematic and commemorative ornaments were sometimes used, referring to games, and the mysteries and sacrifices of their religion—human figures, centaurs, skulls of sacrificial oxen, etc., in metopes. But Greek style of decoration is peculiarly free from symbolism, it being wholly foreign to its pure æsthetic development.

b. Æsthetic.—Art now becomes purely æsthetic for the first time; the principle of beauty is substituted for that of symbolism. Not such a variety of elements as a distinct and entirely new line of development. The very existence and development of Greek ornamental art are based on universal æsthetic laws.

4th.—*Material and its Treatment.*—The colored decorations of Doric period and style gave place to beautiful enrichments carved in relief in the Ionic and Corinthian. Bronze also used, sometimes as panels between cross-beams. Mosaic work of floors—first in simple variegated linear patterns with variously colored pieces of stone, later with figure representa-

tions. Greek ideal forms, beauty of line, correct and expressive application ennobled the decoration of simplest objects of household use. Ceramic wares and metal work show the high perfection of Greek decorative art.

5th.—*Color*, in Doric period, was used most extensively. Cornices were lightly incised and filled in with plain colors, blue, red, yellow or gold and same method sometimes applied to sculptured figures in metopes. Doric polychromatic decoration may account for almost exclusive use of flat surfaces; for high relief, producing shadows, is antagonistic to display of color. In general, dark blue and dark red used on temples, laid on in strong, unbroken tints. Vases—black and tawny yellow, characteristic coloring, but not excluding red, yellow, green or white. Purple and saffron favorite colors for male and female costumes. In later periods color was sparingly applied, whether on plaster or ornamental details in relief. Sculpture was sometimes painted and relieved by strongly marked background.

6th.—*Sculpture and Painting.*—Doric pediment and metopes contain fine examples of Greek sculpture. Ionic and Corinthian friezes, sometimes sculptured, but rather small for much display of human life and action. Those decorative features which were painted in Doric were carved in later styles, when used at all, as fret, guilloche, scroll-forms, astragal, echinus, anthemion. It is to be observed that the Greeks understood the place of sculpture and painting in architecture. For, where used at all as enrichments—sculpture of Parthenon pediment and frieze, or picture in wall-panel—they share the ornamental effect only in general form and arrangement. Examined in detail, they are works of the Fine Arts, not ornaments. Sculptured enrichment does not interfere with architectural features, but accommodates itself to them. The plastic element is kept in subordination to the dominant motive of the architectural.

3.—Characteristics of Greek Composition.

1st.—*Principality* is seen in triangular pediment of all Greek temples, in progression of sculptured figures toward that under summit of pediment, and in use of facade tile and roof pedestals.

2d.—*Size* of all Greek buildings and monuments quite small in comparison to colossal structures of Egypt and Assyria. This is but a further proof of the purity and delicacy of Greek taste in matters of architectural design. As love of the beautiful in nature and art increases, the desire to awe and overpower by massiveness decreases. The pleasing impressions produced by Greek proportions render mass unnecessary; this moderation in architecture accords with all their relations of life.

3d.—*Proportion.*—Greeks had fine instinct for line and beauty in choice of types and proportions, enabling them to make unsurpassed combinations. Ornaments are duly proportioned, however rich, and always kept subordinate to the structural requirements. Temples usually have definite proportions: height about equal to width; length about twice width. Every part proportioned to all those parts with which it was related, in certain ratio; as 1 : 6, 2 : 7, 3 : 8, 4 : 9, etc., and 4 : 5, 5 : 6, etc. Cubic dimensions are in about the same ratio as will be noted in mediæval cathedrals: Parthenon—227 x 101 ft., and 65 ft. high to summit of pediment; great temple of Diana—342 x 164 ft. in plan. Angle of Greek pediment shows rise of about 2 ft., in 7 ft. One of smallest Greek monuments, Lysicrates: square base 9 ft. on side and 12 ft. high, surmounted by the circular monument, 22 ft. higher.

COMPARATIVE PROPORTIONS (APPROXIMATE) OF THE GREEK ORDERS.

Heights of—	Column.			Entablature.			Pediment.	Distance between columns, in terms of diam.	Diam. of shaft, feet.
	Base.	Shaft.	Capital.	Architrave.	Frieze.	Cornice.			
Doric, Parthenon,	—	5	$\frac{1}{2}$	$\frac{2}{3}$	$\frac{5}{6}$	$\frac{1}{2}$	$2\frac{1}{3}$	1	$6\frac{1}{6}$
Ionic, Erectheium,	$\frac{2}{5}$	8	$\frac{7}{9}$	$\frac{5}{6}$	$\frac{5}{6}$	$\frac{5}{6}$	$2\frac{1}{3}$	2	$2\frac{1}{3}$
Corinthian, Lysicrates,	$\frac{3}{8}$	$8\frac{2}{3}$	$1\frac{1}{5}$	$\frac{5}{6}$	$\frac{5}{6}$	$\frac{2}{3}$	—	2	$1\frac{1}{4}$

These proportionate parts are in terms of the usual standard—the diameter of shaft near base. Early Doric shaft was $3\frac{1}{3}$, later $5\frac{2}{3}$; abacus, $\frac{1}{6}$ diameter.

4th.—*Harmony.*—Greek art sought to develop natural and historic forms with artistic freedom into orderly beauty, and to effect harmony in combinations and details, harmony of refined form and delicacy of outline. There is greatest harmony with greatest variety. When modifications were introduced from one order to another, they were made to harmonize with their new environments. The relief outline of each enrichment being described by the same kind of line as the profile of the molding to which it was applied aided greatly the production of harmony. Greek earthenware vessels, painted black or tawny yellow, show harmonious decoration, quite sufficient for their purpose, pure and full of meaning. As regards decorative elements: flat (painted) surfaces and right-line fret series in harmony with Doric; curved surfaces in relief and curved-line series in harmony with voluted Ionic and foliated Corinthian; and the astragal, very often seen below echinus and anthemion moldings in horizontal series, gives harmony and contrast.

5th.—*Symmetry.*—Effect produced by harmonious symmetry and balance. Each detail, each temple symmetrical in itself. Even Erectheium (three temples) has group balanced and arranged. Greek architecture not bound by laws of formal symmetry. Every feature, every detail, every object, such as hall or temple, considered as one complete yet separate whole, was symmetrical and regular. But no two compartments or buildings for different purposes were made to look like one.

6th.—*Repetition* or series is admirably carried out. Greek details admit of every variation, so long as the order or arrangement on which the ornament depends, is not disturbed. Great simplicity of details and arrangement, various elements being usually arranged in simple horizontal series, one row above another. Greek details are repeated almost endlessly, yet with the peculiar charm and variety of artistic treatment as opposed to mechanical methods of reproduction. Zigzag—simplest variety of right lines; fret—more complicated order of right-line series; guilloche and interlacings—similar simple series of curved lines; scrolls—regular running series of spirals (alternated) or forms treated in that order of curve; anthemion—a succession or alternation of an harmonic group of curves. In Greek anthemion there are smaller and larger clusters alternated, reversed or inclosed in a curve, and usually connected by a running band—mere contact of offshoots or simple scroll.

7th.—*Contrast.*—The eye is led from smaller to larger projections through intervening moldings, assisting the contrast between vertical and horizontal lines necessary for animation and stability. The contrasts are not abrupt but gentle, by alternation of projections and depressions in plan and profile. The harmonious contrast of moldings and of the entire cornice is obtained by alternations of light and shade, by individual parts adding to constructive effect of the whole. The buildings are arranged to produce variety in contrast, not formality nor singleness of effect. Difficult to choose forms of less decided individuality than the Greek, which would show as distinctly the fundamental principles of ornament—series and contrast; contrast of masses, and contrast or harmony of lines. All popular ornaments like the Greek are beautiful, not because they represent natural objects, but illustrate symmetry or contrast,—harmony of form and color pleasing the mind through the eye as harmonies and melodies do through the ear. In Doric it is a contrast of color; in Ionic and Corinthian a contrast of masses of light and shade; as echinus, astragal, dentil band and fluted scrolls and volutes. The flutings on shaft give it a varied and animated appearance and emphasize its circular form.

8th.—*Fitness.*—Architectural details, besides constructive reasons, have reference to due and important regard for form; as increasing projections of architrave and its moldings prepare for overhanging corona, while retreating frieze forms intermediate contrasted steps. The enrichments, painted or carved, uniformly assist in bringing out the intention of molding. The natural development of all Greek ornament from an original basis points out the constructive purpose of the design. There is a conscious endeavor to adapt the ornament, with all its richness and refined feeling, to the fundamental form of the object to be decorated, and regard is fully paid to the construction and use of that form.

9th.—*Associations* are decidedly national, so far as it developed in conjunction with the characteristic Greek love of the beautiful, intuitive perception of harmony and desire for moderation. Constructive and ornamental features are developed organically and naturally, aiding comparative study.

10th.—*Style* is quite pure and characteristically Greek from the standpoint of its own development. Art and architecture brought to a refinement, in time of Pericles, which has marked it the typical Greek style, with its three orders,—Doric, Ionic and Corinthian.

III.—Comparative Study of the Greek Style.

1.—In Relation to Earlier Styles.—In early stages (Doric) it is highly probable that the technical processes were identical with the Egyptian. The early Greeks could be well acquainted with Egyptian art and architecture from their commercial relations with that people and from immigrant artists. Proto-Doric columns in tomb at Beni-Hassan and many in temple of Karnac. Proto-Ionic forms—scrolls, guilloche, volutes on capitals—have been noticed in Assyrio-Persian style, and some may be traced back to lotus forms of Egypt. The beautiful expanding lotus-flower capital of Egypt may be a prototype of the Corinthian capital, similar in form and treatment, but local plant (acanthus) used. In fact, it is only needed to inquire into the source of the idea or motive, because local natural forms

supply the elements for conventional treatment and adaptation of the motive. It is so in all the great styles; where motives have been transplanted they must be developed in keeping and in harmony with their new environment. The principle of the compound flower cluster is seen in the lotus cluster of Egyptian, the palmette cluster of Assyrio-Persian, the anthemion form of Greek, and will be noticed later in the acanthus cluster of the Roman style and fleur-de-lis of the Gothic. Simple forms repeated in series are disconnected in Egyptian but connected in Greek; as, Egyptian discontinuous fret and Greek continuous fret and anthemion. The vein of poetry animating the political, religious and social life of the ancient Greeks enabled them to blend artistic forms of other nations and develop their own to an unparalleled degree of refinement.

2.—In Relation to its own Development.—Two distinct varieties may be noted, Doric and Alexandrian, the severe and the florid. The Dorians first brought their style to perfection, yet characteristic of their life—Spartan in its simplicity, strength and severity. The Ionians developed some of their greatest architecture in Asia Minor; but it was in combination with Dorian influences that it reached its most graceful forms in the Erectheium, —of the florid, Alexandrian variety. Doric and Ionic were earliest and oftenest employed for temples; the entire structure in both orders rests on same fundamental principles. The Doric expresses itself in the building as a whole as well as smallest feature. The Ionic expresses itself as a whole and in details, which are finer and more numerous, richer and more elegant. The Doric is best seen at a distance, the Ionic near by. Though Ionic is possibly indebted to Asiatic influences in early development, yet its later beauties are to be attributed to Doric infusion. While the main structural elements are much the same, the ornamental forms are quite different—Ionic has more moldings and carved details, and as a style is lighter and more graceful than Doric. The Corinthian order was only introduced before period of decline, and belongs to the Alexandrian variety. It differs from Ionic chiefly in having the acanthus capital, though the proportions are somewhat lighter and more slender. It was not used by the Greeks as a temple order. An archaic severity, with heavy proportions and more strength than grace, marks the early, or Doric variety. Dignity, sobriety, refinement, elegance and beauty are qualities of the later and best, or Alexandrian variety.

The development of particular forms, due to environment, are the pediment and frieze. Rainy seasons of Greek climate required sloping roof—the gable which developed into the beautiful pediment. A new member was called for in the entablature—the frieze. This diminished apparent weight of pediment, balanced the parts, and strengthened in effect the entablature. The ordinary scroll and acanthus are less used than echinus, astragal and anthemion. The simple scroll and acanthus foliations in the finial surmounting roof of Lysicrates' monument are best Greek examples. Greek constructive and ornamental forms show a knowledge and application of natural laws. Architectural forms suggest life and energy coming in contact with pressure or resistance from above. Pottery, one of the oldest arts, has given architectural ornaments for almost all of the ancient styles. Probably nowhere has this use of vase ornamental features in architecture been so marked as in the Greek.

3.—In Relation to Later Styles.—A taste for the magnificent, luxurious and colossal prevailed toward the end, during reign of Alexander. It savored largely of the growing tastes of the Romans, which so soon developed and brought about the decline likewise of their art. The Corinthian order occurs in later Greek examples during Roman period, and especially is this a marked order of the Roman style. The decadence of Greek art and architecture seems to give birth to the Roman Those forms so rarely used by the Greeks—the acanthus, scroll enrichments, foliated capital—become prominent features in Roman. In one sense, the Greek style ends where the Roman begins. The Corinthian becomes a temple order, and a new order, the Composite, is developed out of the acanthus capital combined with the echinus and volute.

Greek art and architecture have influenced all the styles since. We still use the forms and the very details adopted by the Greeks. This seems on account of their small individuality rather than specialty of detail, of their being beautiful on universal grounds of æstheticism rather than peculiarly local types.

SECTION IV.—ROMAN ARCHITECTURE.

I.—Historical Outline of its Development.

The *Etruscans* in Italy sprang from same Pelasgic stock which emigrated from Asia Minor about the 12th century B.C. Their architectural works resemble those of early Greek colonies of Pelasgi, especially in vases, ornaments, early temples, tombs and Cyclopean masonry. But more circular forms were used, as in circular tombs (tumuli) and round arch construction. Early art history of Greece and Rome quite similar: both sprang from same parent stock, Pelasgi, which Turanian civilization was superseded by Aryan, or Indo-Germanic.

1.—Early Republic. (Founding of Rome—Subjugation of Greece, 753–145 B.C.)—Early inhabitants of Rome probably came from the North. On one side was the growing Etruscan nation, contending with the young Roman republic for supremacy, finally becoming subject to Rome about 330. As usual, the conquering adopted the elements of the arts of the conquered and built thereon a far richer style. Works of great engineering were undertaken—sewers, aqueducts, bridges, gates, harbors, roads and few palaces and temples; accuracy and skill of workmanship; more attention to construction than decoration; round arch and arcades; public utility and convenience, solidity and durability, masculine simplicity and magnitude the chief characteristics. On the other side was Greece, developing art along lines of beauty rather than utility, whose subjugation with the decline of her art gave rise to a new development of Roman art.

2.—Later Republic. (Subjugation of Greece—Beginning of the Empire, 145–27 B.C.)—Increase of wealth, influx of Greek ideas, decorative work of Greek artists, caused erection of public and private buildings with an elaborateness before unknown. The great diversity of objects marks a scientific and structural advance upon all preceding styles—temples, palaces, baths, theatres, amphitheatres, basilicas, aqueducts, bridges, gates, triumphal arches, all of which were put up with still greater magnificence under the Empire; for Augustus, finding Rome in brick, left her in marble.

3.—Early Empire. (Augustus—Trajan, 27 B.C.–98 A.D.)—The opulence and luxury of the East poured into Rome and diffused a general ardor for splendor, magnificence and costliness in all works of art and architecture. This Augustan age, the period of full development, is the most brilliant in Roman history. In all countries under Roman dominion great public and private works were carried out after the style of the architecture of the imperial city, in some cases with slight modifications due to local influences and environment. After burning of Rome by Nero (65 A.D.), it was rebuilt with magnificence exceeding all bounds.

Temples were insignificant compared with other great buildings in Rome. Small circular temple of Vesta, inclosed by 20 Corinthian columns of beautiful and slender proportions. Others were rectangular in plan—modified Greek; few remains. Great temple of Jupiter Olympius, at Athens, finished by Hadrian;—decastyle in front; double range of 20 columns on each flank, about 58 ft. high; most elegant Roman-Corinthian order; 171 x 354 ft. in plan.

Pantheon, in Rome, is finest example of temple. Circular in plan, covered by a dome; later was added a rectangular portico, similar to that of Greek temple, with pediment supported by 16 Corinthian columns, whose smooth shafts are single blocks of stone. Interior ornamented with statuary in niches, between columns, profusion of carved ornament, and recessed panels in dome.

Palaces on grand scale and laden with rich trophies of Roman conquest and most costly materials to be found in her dominions; interior specially rich in decorative and constructive ornament. Palace of the Cæsars on the Palatine Mount, Rome, is the most remarkable.

Baths were simple structures, at first, without any kind of ornament. They possessed, later on, that luxury, elegance and extravagance throughout characteristic of the decline of Roman art; covered great area, with many small divisions and compartments, porticoes, gymnasia, lecture-rooms and other halls for exercises and recreations of mind and body; highest architectural skill employed in interior decoration and arrangement. Baths of Diocletian and of Caracalla, in Rome, best remains.

Domestic buildings became palatial in appointments and interior finish; exteriors seem almost neglected; great inner courts, fountains, baths. Finest examples at Pompeii, (destroyed 78 A.D.).

Tombs were given more consideration than possible for Aryan people, which shows strong infusion of Turanian blood from Etruscans. Early tombs, hewn in rock, or subterranean vaults, in which were deposited the urns holding ashes of the dead. Later tombs in form of circular towers, on square basement, all of bold masonry. Still later ones were simply circular, surmounted by dome, and largely used by early Christians—prototypes of what later on were used as Baptisteries.

Theatres were not so much used nor so essential as in Greek cities. Finest provincial theatre, semicircular in plan, at Orange, southern France.

Amphitheatres are more typical of Roman architecture. Colosseum, at Rome, the greatest; elliptical in plan, 620 x 513 ft., and 157 ft. high; external walls consist of three arcades, one above the other, bordered or faced by half-columns of Greek orders—Doric, Ionic, Corinthian—with respective entablatures arranged in usual Roman fashion; fourth story is almost a

solid wall, marked off by Corinthian pilasters; exterior of stone, interior of brick. The use of the Greek orders, in storied construction in the Colosseum, began with the Romans, and is quite typical of their style.

Basilicas, or Halls of Justice, are as important as they are remarkable. Rectangular in plan, with semicircular recess, or apse at one end; columnar construction internal; roof vaulted. Sometimes used as commercial exchanges, they were later used as early Christian churches.

The *Forum* was a large rectangular open space closed in by a colonnade, and surrounded by basilicas, council chambers, temples, exchanges, schools and other public buildings. It was the great centre for all kinds of business.

Triumphal Arches to commemorate great deeds of rulers or victory in war. Arch of Titus, on road from Forum to Colosseum, in Rome, in memory of taking of Jerusalem—single round arch between two half-columns (Composite), supporting an entablature; bas-relief ornament represents spoils from the Temple at Jerusalem.

Bridges and Aqueducts, as works of civil engineering rather than architecture, were of most substantial construction—many fine examples throughout the Empire. Aqueducts, chiefly of brick, with lines of arches one above the other. Bridges had level roadways supported by massive arcades whose arches decreased in size to either shore.

4.—Later Empire. (Trajan—Constantine, 98–325 A.D.)—The period of decline has set in. Roman luxury, extravagance, sensuality, magnificence and the political complications of the later empire presage the end.

Triumphal Arches of Septimius Severus and of Constantine (Rome) have side arches between the side columns, and a large central arch. Profusely decorated with figure-sculpture; inscription on entablature.

Columns of Victory. Trajan column, in his basilica, most noted—square pedestal supports a Roman-Doric shaft surrounded in its length by a spiral belt in rich relief, ornamented with scenes commemorative of the Dacian expedition, 101 A.D.

Basilica of Trajan (Rome) has large central aisle covered by vaulted wooden roof; the two side aisles on each side of main aisle have galleries above, with upper rows of columns, from the tops of which spring the arches of side and centre aisles; plan as usual; interior more important than exterior, and received more consideration in the design.

Basilica of Maxentius, finished by Constantine. Plan as usual, but wider in proportion to length; no pillars as such, but in front of each of the eight piers of centre aisle is placed a column and small entablature; this is merely as constructive ornament, and similar to Gothic vaulting shaft, giving appearance of support (though none in reality) to the springing of the vaults; three great intersecting vaults over centre aisle; aisle on each side roofed by barrel vaults; arch thrusts collected at points and buttresses there placed to receive them; many of these peculiarities of vaulted construction to be noted later in Gothic buildings.

Early Christian Art developed while the ancient Roman declined. The feelings of mankind gradually undergo a change in this period, and seek other forms of utterance, other forms of expression in art and architecture. What really belongs to Pagan and what to early Christian art may be pointed out by recognizing the peculiar symbolism of the latter as opposed to the richness and æstheticism of the former.

II.—Analysis of the Roman Style.

1.—Characteristics and Elements of Construction.

1st.—*Site*, in general, chosen for utility, to meet requirements of Roman business, political and social life; few elevated spots.

2d.—*Planning.* Circular,—temples and tombs; semicircular,—theatres; elliptical,—amphitheatres; rectangular,—temples, palaces, baths, forum, basilica (with semicircular end), triumphal arches; square,—basement of tombs, plinths and pedestals for columns which were almost always used to raise the shaft and adapt the columnar to the arched construction. Steps usually led to temple only on entrance side; foundation wall carried forward to outmost step, in some instances forming high pedestal for angle columns of portico. Many buildings of later date show interior columns more than exterior; as, Pantheon, basilicas, domestic buildings. Others show magnificent external arrangement of columns; as, Jupiter Olympius, temple of Vesta, portico of Pantheon, porticoes of baths, forum colonnade. Storied arcade construction, as in aqueducts and Colosseum; orders arranged one above the other, historically—Doric, Ionic, Corinthian.

3d.—*Material.*—Brick and small local stone much used throughout; in early period as principal material, in later as backing and for interiors. Many varieties of beautiful marble imported from the provinces for costly shafts, exterior or interior finishing, etc. Mass of material used in small shape; though single shafts and blocks in Rome, and the great blocks at Baalbec, show that large masses were occasionally used.

4th.—*Structural Elements.*—Etruscan circular forms throughout; later, Greek rectangular and lintel forms. Aqueducts and bridges show typical use of round arch in simple arcade construction; arches spring from capstone or simple abacus on top of square or rectangular pier (tapering).

Roman Arcades.—Greek orders coming in were combined with Etruscan arcade, not structurally but ornamentally; for the Greek columnar construction forms only a facing for the wall surface, breaking up its monotony in a questionable manner. The columns are placed from one another about equal their own height, below a long entablature, supported in the centre by a round arch springing from piers. This combination called for a new arrangement: columns were mounted on pedestals, a projecting keystone was introduced into the arch, and the architrave (losing its structural significance) was either omitted or much reduced. The arch, later, appears to spring from the cornice of a small high entablature, but really from a massive pier behind the column. In other instances no entablature was used, but arch sprang directly from abacus of capital. Sometimes the whole entablature was bent around to the form of the arch.

Domes and vaults developed out of this arched construction: the dome for circular buildings, the barrel vault for rectangular and the intersecting vault for square spaces. The diagonal ribs formed by the intersecting vaults carry thrusts to main piers.

Roman orders all have molded base, and usually rest on square plinth or pedestal. Half and three-quarter columns and pilasters were counterparts of the columns belonging to their respective orders. Pediment at greater angle, higher than Greek.

Roman-Doric was a modification of earlier Etruscan and Greek-Doric: base, a square plinth supporting heavy torus molding and fillet, other bases

similar to Attic; shaft, smooth and tapering; plain bead and fillet short distance below capital; narrow echinus beneath light square abacus; architrave narrower and entablature plainer than Greek. The so-called Tuscan order is only a modification of Etruscan, with better relation of height to diameter. Roman-Doric has not the simplicity, dignity and strength of the Greek, shaft more slender, necking, capital and entablature moldings more projecting, outline too swelling. There is no Roman-Doric temple.

Roman-Ionic seldom used for temples, but, as with the Doric, more in arcade construction. Attic base; shaft fluted; compressed and mechanical volutes usually arranged diagonally in capital, with insignificant echinus between volutes; absence of the delicacy and elasticity of the Greek form; entablature heavier, outline more formal.

Roman-Corinthian a rich development of the Greek. Attic form of base with molded scotia is elegant and appropriate; shaft of most pleasing proportions, acanthus capital, almost over-ornamented, seems just suited to its office. But entablature falls short of expectations; architrave too richly carved; frieze plain; cornice excessively decorated. This order constantly used. Greek types partly adhered to. Ionic dentil band and Corinthian modillions somewhat altered in form. Shafts fluted or plain.

Composite order was an attempt to combine all three Greek orders at once—echinus, volute and acanthus. Its distinctive feature, the capital, grew out of attempt to strengthen upper part of Corinthian, whose delicate volutes were removed and the Ionic put in their place. The union of these two dissimilar things failed to combine the beauties of either.

5th.—*Stability* throughout, especially in early constructions and engineering works. Insured by great area of supports, as in Colosseum. Solidity of workmanship is combined with grandeur of design and richness of decoration.

6th.—*Durability* remarkable, when brick construction was almost universal. But their system was admirable, and showed careful masonry, thorough bonding, and use of good mortar.

7th. *Sanitary.*—Great sewers, as the Cloaca Maxima, emptying into Tiber, with round arch vault; miles of aqueducts; disposal of dead by cremation—ashes preserved in urns in cellular tombs. Light admitted by windows and open porticoes; Pantheon lighted by single circular opening at top of dome; basilicas sometimes lighted through upper colonnade at side of central aisle, an arrangement common in early Christian churches.

8th.—*Execution.*—There is great constructive skill combined with vastness of proportion. Early structural elements, arch and lintel, were put to new uses and new forms devised—dome and vaulting systems. Roman structures have that size and impress of power which are too often their only merit. They seem to have mastered skillful construction more than beautiful ornamentation.

2.—Characteristics of Roman Decoration.

1st.—*Kind.*—(a) *Constructive* ornament more used than in any preceding style. Greek columnar orders and modified entablatures as vaulting shafts or facing for arcade.

(b) *Decorative.*—Moldings circular in section and profile, and almost always richly decorated (carved); have little or no relation to their position,

but are very bold in form and enrichment. Ionic dentil band sometimes used with Doric triglyphs. Festoons and garlands on frieze occasionally. Paneling extensively used under cornices, under arches, in ceilings, vaultings and domes; sometimes enriched with bronze patera (rosettes).

2d.—*Forms.*—(a) *Geometric* forms, chiefly in interior paneling and tessellated floors,—triangle, square, lozenge, hexagon, octagon, star-forms, almost all of which were highly enriched with elements modified from Greek.

(b) *Conventional* foliage, as well as almost all Roman ornament, taken from florid Greek, of which it is simply an enlargement or enrichment. It did not add a single important element to the Greek style, but elaborated the established elements with every possible variety of effect. The richness and exuberance of which it was capable developed into colossal proportions. Roman style original only in its treatment of the Greek materials.

Roman acanthus forms were almost imitated from nature, not advisable if allowable in architectural decoration; but they were formally disposed. The acanthus scroll and acanthus rosette are most common; in fact, the scroll is seldom seen without the acanthus enrichment. The acanthus mollis, or soft acanthus,—the brank ursine, most used; sometimes replaced by conventional olive leaves in capitals of lofty temples. Later forms more conventional, unrecognizable, and lifeless: acanthus, olive, and vine.

Animal forms and monsters more freely used than in Greek—sphinx, triton, griffin, chimera. Figure elements and conventional foliage are often combined, naturally or æsthetically, rarely symbolically.

3d.—*Classes.*—(a) *Symbolic* elements are chiefly in relation to sacrifices, as ox-skulls, and of similar signification to Greek.

(b) *Æsthetic.*—Though the Romans took their ornamental forms from the highest æsthetic style, they seem to have cared little for the principles underlying their design, and to have been wanting in true æsthetic taste.

4th.—*Material and its Treatment.*—Etruscans reached high technic perfection in ceramic art and metal casting. The Romans sought to embellish even commonest household objects. Ceramic and metal work, craters, amphoræ, table supports, seats, candelabra, lamps, bowls, weapons, trinkets, etc.; wrought and molded work in precious metals, and engraved glass. Bas-relief in figure-sculpture, high relief in foliaged sculpture, with occasionally deep undercutting. Sculptured panels in new Rome, painted or gilt in relief on blue ground, and decorated with bronze, mother of pearl, onyx, agate, jasper and other precious stones. Baths embellished with costly marbles and brilliant frescoes. Floors tessellated or mosaic, with colored materials. Stucco and clay, relieved by color and tinted background, took place of marble in Pompeii.

5th.—*Color* lavishly used, but especially on interiors. Pigments, colored marble and precious stones.

6th.—*Sculpture and Painting* and statuary used in great profusion, especially interior. Paintings more than sculpture embellish later Roman interiors, and almost exclusively at Pompeii. Walls decorated with paintings and ceilings with sculptured moldings. Much scenographic or perspective representation on walls. Subjects chosen appropriate to character of edifice—monumental buildings and triumphal arches, historical subjects in a severe style; private houses, light and fantastic subjects; public edifices and temples, political or religious subjects.

3.—Characteristics of Roman Composition.

1st.—*Principality* to be seen in temples, (Pantheon), triumphal arches and basilicas.

2d.—*Size.*—Roman buildings uniformly more massive than Greek, bolder in details and treatment of ornament.

3d.—*Proportion* not so carefully thought out as in Greek buildings. Roman columnar orders had fixed and definite proportions, and were not adapted for each particular building by the architect. Strict laws were formulated and proportions were governed by a constant tendency to formal symmetry, thereby losing the attractiveness and beauty of the almost undefinable Greek proportions.

4th.—*Harmony* is wanting in some very typical Roman buildings; as the Greek pediment and portico in front of overtowering dome of the Parthenon. The use of the three orders, one above the other, did not harmonize the construction with the ornament, and harmony is lacking in even best Roman-Doric and Composite.

5th.—*Symmetry* fully developed in plan and elevation, and in ornamentation. Use of rounded and circular forms and elliptical plans conduced to this.

6th.—*Repetition* throughout as marked a feature as in Greek. Arcades and arrangement of these, story above story, as in Colosseum, give effect of imposing grandeur.

7th.—*Contrast* marked in use of Greek columnar with Roman arcade construction. Almost everywhere the round seems brought into contrast with the straight.

8th.—*Fitness* almost lacking, especially the admirable consistency to be seen in Greek design.

9th.—*Associations* are quite true and in keeping with Roman love of display and grandeur, magnificence and show of power. Structures adapted to their purpose—largely utilitarian.

10th.—*Style* possessed by some Roman buildings; as Pantheon, Colosseum, basilicas; also noticeable in triumphal arches.

III.—Comparative Study of the Roman Style.

1.—In Relation to Earlier Styles.—The art of Rome was not a pure and natural growth of the soil and people, but was gathered in a transitional period of the world's history from foreign styles. At first, Etruscan art had rather Oriental features, especially Assyrian—animal forms in remains of architectural decoration, fantastical scenes in black on earthern vases, and numerous bronze vases. Later, Etruscan vases approximate the Greek and lose their own peculiar character. Roman architecture shows constructive forms derived from Etruscan, and ornamental forms derived from Greek, with such new developments as naturally rose out of, or were suggested by, these combinations, in the peculiar environments of Roman life. Greek taste progressed till Alexander. From this time richness and abundance of ornament gradually supplanted the more chaste principles of Greek design. The conquest of Asia brought in Oriental love of display, which ended in pure ostentation in art, finally destroying taste and true art itself, under the luxurious example of the Roman emperors.

Roman buildings are of greater proportions than Egyptian, more varied than Greek, yet affect to combine the beauties of both. The tastes of these three styles are very distinct—Egyptian is symbolic, rich and severe at the same time; Greek is beautiful and severe; Roman is beautiful and rich in its best examples.

2.—In Relation to its own Development.—Though the round arch was known to the Egyptians, Assyrians and Greeks, they did not use it as a distinct element, excepting, perhaps, the Assyrians. From the arcade, the Romans proceeded to remove the pier and substitute the pillar without pedestal—a change as the outcome of many trials and expedients. The covering of spaces with domes and vaults had fairly begun when it was left for others to develop.

There is a transition from external to internal columnar construction, from external decoration to internal embellishments. This may have been due to climate, and the habits and temperament of the Roman people.

Great variety of purposes characterizes Roman architecture. It variously applied the orders and details, intended by other nations only for temples. But in time of Constantine, the Roman columnar orders were much less used, chiefly for decorative purposes. Bridges and aqueducts were the only works which the Romans executed without affectation and with all their originality and power.

In its decline quantity took the place of quality, and was applied without taste or propriety. The great abundance of materials gave only more opportunity for their inartistic use. For it must be noted that style and system are of similar import in ornamental art. Besides correct style in the ornaments themselves there must be system in applying them. If the characteristic members of certain established styles are thrown together promiscuously, the principal details of one style applied as secondary to subordinate features of another, the value of all is diminished, and its general effect is vagueness. The same types of ornament may be used in the development of new styles, the mode of using them marking the distinction quite as much as the forms themselves. The elements belonging to any one style limit it, however, when developing into a particular historic style, so that the various members of the same style should keep their relative degree of importance when combining styles. Now, the general decorations of the Roman style, and those of Pompeii in particular, utterly disregard these principles, so all distinctions of style and peculiar characteristics are lost.

3.—In Relation to Later Styles.—Architecture of the middle ages had its germs in that of Rome. The division of the Empire, and the removal of the capital to Byzantium (Constantinople), mark an era in architectural history. The semi-Oriental nation took its own circular forms, changed them to its purpose, and from the Pantheon developed the great domical system of Saint Sophia, giving rise to the Byzantine style. Roman basilicas were taken for Christian worship; and, being simple, at hand, or inexpensive to build, they came to be favorite forms, with the apsidal end for the altar. So the nations of Western Europe appropriated the rectangular form of the basilica, with its apsidal end, vaulted roof and internal colonades, giving rise to the Romanesque style.

PART III.

Architecture of the Middle Ages.

SECTION I.—TRANSITION FROM CLASSIC TO MEDIÆVAL ARCHITECTURE.

I.—Historical Outline of this Period.

From the dawn of Christianity architectural history assumes a different character. The new influences at work, the new thoughts scattered by a chosen few, are not without their effect upon the lives of the many. In Rome, and in her art and architecture, the new religion shows great influence. Side by side with the decline of ancient art is the inception and growth of early Christian art. This transition was not completed till Constantine, so far as it relates to the beginning of the new style at Byzantium. In Italy and south of France, modified classic Roman forms continued even till 7th century.

II.—Analysis of Early Christian Architecture.

The elements of construction essentially those of later Roman style—basilicas, tombs, monumental buildings, converted into churches. The portions most richly decorated: chancel arch between apse and nave, apse, altar in shape of table, cathedra or bishop's seat, pulpit, cleansing place, baptisterium, altar vessels; flat ceilings often paneled, wall plates and roof generally colored with paint. In minor art work the antique (Roman) elements prevailed. Constructive arrangement brought painting and mosaic forward as almost exclusive surface decoration.

Christian art was limited, during 1st and 2d centuries, to symbols not applied as decorations, but as exhorations to faith and piety. Its general characteristic is aspiration: distinct allusions to life and death of Christ; new doctrines represented by symbolic forms, adopted from animal and plant life; placed with symbolic reference in churches and dwellings; abolished the images, symbols and luxurious decoration of Roman. The Cross most prominent of all allegorical symbols; various forms, singly or with circles and disks. The good shepherd, lamb, hart, peacock, fish and serpent; aureole, vesica and nimbus; vine and lily, all favorite symbols of attributes, promises and virtues, and freely used on facade, portals and interiors.

Later on there is conventional imitation of antique ornament. Most diverse fragments of Roman art used without scruple. Very rarely the new product equaled the antique types, motives being far from agreeable, as rush leaves for delicate acanthus.

III.—Comparative Study of Early Christian Art.

In it, as in Egyptian, beauty of form is entirely subordinate to symbolic value of the decorative elements; architectural details enriched in both by giving preference to certain emblems which had become generally comprehended. All Christian decoration rests upon this foundation—symbolism the prevailing spirit, till return to principles of beauty (æstheticism) in the Renaissance. The circle, or nimbus, is the element of trefoil and quatrefoil, so common in Byzantine and Gothic; the first symbolizes the Trinity, the second the four Evangelists; and the nimbus the glory of the head as the vesica is of entire body. Sometimes the four circles of the Evangelists surround a central one referring to Christ. Combinations of three, four and five circles, common in mediæval art, have sacred meanings.

SECTION II.—BYZANTINE ARCHITECTURE.

I.—Historical Outline of its Development.

1.—Formation of the New Style.—Byzantium re-established as Constantinople (324) and seat of Eastern Empire, under Constantine the Great. He build Santa Sophia, which being later burned to the ground was rebuilt by Justinan (562). Noted for its size, span of vaults, great central dome, and unsurpassed splendor of interior decorations, it has become the typical building—a model for all later ones in this style.

Santa Sophia.—Ground plan nearly square (230 x 252 feet). Four massive piers connected by semicircular arches form great central square, at corners of which triangular vaultings (pendentives) span the arches and support great flattened dome. Right and left of dome-covered square are vaulted galleries, while at each end is a semicircular apse supporting a lower semi-dome. This is penetrated by three smaller vaults: central one is cylindrical and forms main entrance at one end, while at opposite end it is rounded off with semi-domed apse; the remaining vaults, one on each side, are in form of great niches with semi-domes, resting on upper row of columns. Two-storied side aisles are around great central square, except on altar side, and are supported by an upper arcade above a lower. Walls, piers and floors inlaid with colored stone; vaults enriched with mosaics on gold ground; columns of various precious and costly marbles. Exterior plain and uninteresting; vaulting of dome visible or only covering one of polished metal.

2.—Fully Developed Style.—In the East, Oriental forms, chiefly Arabian after invasion of Arabs, exert a marked influence in Byzantine art, and it in turn had a reflex action upon Arabian. In the West, Byzantine is brought in contact with the growing Western art, especially at Venice. Here the two great styles met in the cathedral church of St. Mark's.

St. Mark's (1070).—Ground plan a Greek cross, with dome over each arm and great dome over central square. Intersection of nave and transept forms the cross, and piers at four points of intersection support hemispherical dome. Small apse on each side of main apse, opposite entrance. Barrel vaults of arms of cross converted into semicircular pediments and upper portions terminated by rounded lines. Walls lined with costly marble slabs; substantial floor mosaics, and splendid ceiling mosaics on gold ground. Columns exterior and interior, of costly and beautiful marble. Windows in galleries narrow and round-arched, or double, made up of two small round-arched windows. Doors square headed (lintel), with round arch above. Entrance of receding arches supported by columns of variegated marble and patterns.

Byzantine art spread wherever the Greek Catholic religion secured a foothold and developed into a settled system. The symbolic forms are bound up in the ceremonial of that faith, and, with the structural features noted, continue in use to-day in northeastern Europe and Asiatic countries. It has greatly influenced the development of native art, as in Armenia, Georgia and Russia. On east coast of Italy the influence of Rome and Constantinople was felt at same time, as in San Vitale, at Ravenna. Many Byzantine elements were communicated to the West through commerce and returning crusaders.

II.—Analysis of the Byzantine Style.

1.—Characteristics and Elements of Construction.

1st.—*Site* for churches often central, and clustered around them are other religious edifices, public buildings and monuments.

2d.—*Planning.*—The five-domed vaulting system of St. Mark's, on plan of Greek cross, is characteristic. In this style, more than in Egyptian, is constructive symbolism as distinct from decorative symbolism—structural forms as peculiar and significant as ornamental. Round arch and dome preserved by Byzantine Greeks more for their symbolic value than as mere historic examples of Roman style. Great central dome—the vault of the heavens whose living glories were represented on its spherical ceiling; a smaller dome over each arm of the cross; on the pavement below the five great circles corresponding in size and situation to the domes above them; vaultings and ribs of dome, barrel and cross vaults visible on outside, or covered by tiles, or slabs of stone, when required by climate or Western ideas; semicircular ends for projecting cylindrical or barrel vaults.

3d.—*Material* chiefly stone; small stones and bricks more for decoration. Wall slabs replace stucco and plaster work.

4th.—*Structural Elements* are the cross, circle, round arch, arcade and dome. Walls no longer are principal supports for vaulting, as in Roman; but the pressure and thrust of the vault distributed only at certain points and there received by massive piers. Vaults held together by counterpoise on outside of dome, and strengthened by buttresses. The change from square plan to circular dome effected by triangular vaultings (pendentives) at corners of square.

Columns are subordinate to vaulting system. Between large piers they support the arches of the intermediate arcade. Base is modified antique, shaft generally smooth, capital usually cubiform, with lower corners rounded off or tapering downward. Arches spring directly from capital or from a small block in form of inverted frustum of square pyramid.

5th.—*Stability* shown by peculiar shape of capital, which expresses more supporting power than possible in Roman. The wedge-shaped block on top expresses that stability for Byzantine arched and vaulted construction which the small square abacus does for the Egyptian lintel construction.

6th.—*Durability* not so well secured but that constant supervision and repairs are needed in mosaic floors, wall slabs, arches, vaults and domes.

7th.—*Sanitary.*—Peculiar method of lighting by windows around base of dome produced splendid effects of reflected light from brilliant gold mosaics in dome. Windows occasionally placed in walls as single, double or triple lights.

8th.—*Execution* in almost all cases skillful and thorough. The use of small-sized materials, and the system of arcades, walls and domes called for special care and attention to details.

2.—Characteristics of Byzantine Decoration.

1st.—*Kind.—a. Constructive.*—The capital makes the change required, from circular column to square support for arch, by its cubical shape, with the four faces slanting inward from above. Some capitals have almost straight faces, slanting inward as before, decorated with interlaced work and straight-line figures, resembling a basket pattern. The Byzantine convex capital is cubiform, with lower corners rounded off and decorated with highly conventional foliage and symbolic elements. Greek-Corinthian with pointed acanthus leaves, Roman composite, and modified acanthus capital with Ionic features, are sometimes seen.

b. Decorative.—Typical capitals, cubical and basket-shaped, did not attain the beauty of classical forms and varied greatly in decorative features. Animal forms, scroll-work,emblematic symbols, together with most varied foliage, framed in ribbon-like strips, adorned with net-work or foliage. Moldings of cornice and arch, chiefly antique forms, modified; sometimes made up of row of bricks in zigzag. Frames of windows and doorways often richly molded and decorated.

2d.—*Forms.—a. Geometric.*—Cross, circle, cube and other forms in mosaics.

b. Conventional treatment of all natural forms, as required by the rigid symbolism. Figure mosaics are stiff and conventional. Every representation of a saint had prescribed color, symbols and proportions. Running foliage often meagre. The lily appears in great variety of forms, especially in later work. Finials for scrolls and running borders are often lilies, or leaves of three, four or five blades. The Greek acanthus is formal and sharp, resembling ordinary thistle or holly. Byzantine treatment of antique details shows but slight study of the natural forms of the motives, as acanthus, olive leaves, etc.

3d.—*Classes.—a. Symbolic* forms are chosen more for their meaning than their beauty. Yet, the most beautiful Byzantine designs are those in which the symbolism is unobtrusive, or even wholly disguised. Symbolism is rarely, if ever, absent; in some form or other it is paramount and often mixed with geometric forms. Many forms which seem to be floral are often only combinations of conventional types derived from the symbols; as, circles, vesicas, nimbus, etc. Serpent figures are conspicuous, and sometimes make up entire tracery, symbolizing the Fall and one type of the Redemption. The cross-form is found with the serpent figure, sometimes planted on it, or surrounded by so-called Runic knot, or with two scrolls at its feet. Northern crosses are conspicuous for their interlaced ornament and grotesque monsters. In construction and decoration there is most extensive use of the five circles, or glories.

b. Æsthetic ornament almost reached, in later period, by the ingenuity which worked out from crude symbols beautiful and elaborate designs. But the early designers seem to have avoided rather than sought beauty in their peculiar forms.

4th.—*Material and its treatment* bring out the beauty and effect of Byzantine ornament quite as much as its form. Geometric floor mosaics

of colored stone; wall surfaces relieved by alternate layers of stone or colored bricks, or variegated slabs of stone; brilliant wall mosaics of fragments of colored stone or glass; ceiling and picture mosaics on gold ground; costly marble shafts. Byzantine dislike for plastic art led to extensive use of wrought metal work and art of enameling. Supports of altar canopy artistically wrought in precious metals and gems; brilliantly colored screen inlaid with gold and silver. New forms were created for the vessels and appliances of public worship, giving rise to small, columniated temples, candelabra, censers, variously shaped flagons, crosses, chalices, columbaria, bowls, crowns, lamps and chandeliers, with richest variety in application of Byzantine details. Carvings were in rich relief, yet in some instances show rougher and more unpleasing treatment than the classical. Sculptured leaves are more or less channeled in V-shape grooves, sharp-pointed and often pared round obliquely at the edge.

5th.—*Color* is scarcely restricted. Figure mosaics, arabesques and frescoes often on dark-blue ground, but later on gold. Miniature paintings show red, blue and green, usually on gold ground.

6th.—*Sculpture and painting* not so frequent as in the classical styles. Sculptured figures or groups were very rare, being prohibited by canonical rules. Rich figure mosaics take place of paintings on walls, ceiling of dome, and semicircular space over lintel of doorway.

3.—Characteristics of Byzantine Composition.

1st.—*Principality*—central dome, with smaller domes and apses around it.

2d.—*Size*, from Oriental love of grandeur, influenced Western buildings.

3d.—*Proportion* almost abandoned. Columns and capitals somewhat arbitrary, possibly due to the varying requirements of arcade construction.

4th.—*Harmony* noticeable in external effect, which depended largely upon harmonious arrangement of domes and arched ends of barrel vaults.

5th.—*Symmetry* in plan and elevation, and in many elements of ornament.

6th.—*Repetition* is opposed by the greatest variety of columns and capitals, but is seen in geometrical mosaics for floor or wall patterns.

7th.—*Contrast* in symbolic forms and especially in use of color.

8th.—*Fitness* scarcely thought out in the Byzantine arbitrary arrangement of antique forms. Significance and object of fundamental forms of the several members often ignored, as in cornice and arch moldings. But there is special fitness in the new forms devised, whether structural or ornamental.

9th.—*Associations* quite faithful to the struggle of the early Christians to develop an art and architecture of their own. Most marked are those symbolic forms in which they cast adrift entirely from the antique and seem about to develop a new style on first principles. But the antique forms of the West and the luxuriousness of the East were too seductive and ready to hand; besides, a greater work required their immediate attention.

10th.—*Style* in the Byzantine as in the Egyptian, depends chiefly upon its individual and symbolic character. Yet the vaulted and domical construction, in the West so unsuited and subordinate to the columnar construction, here assumes an independent character.

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III.—Comparative Study of the Byzantine Style.

1.—In Relation to Earlier Styles.—The round arch, arcade, vault and dome are founded on Roman originals, but modified by the Greek-cross plan and developed into a settled system. Antique ornament fared not so well, but rather degenerated, when its decorative principles were set aside and changes made in its details and their manner of application. In its early details the Byzantine treatment is much like the Egyptian—simple, rigid, severe, highly conventional and symbolic. Later forms present novelties and peculiarities undoubtedly due to Oriental influences.

2.—In Relation to its own Development.—The interior arcades and vaulting system develop a new proportion of columns and more appropriate capitals. The architrave, antagonistic to vaults and domes, is abandoned. Semicircular ends, rather than triangular gable or pediment, predominate in consequence of dome and vaulted roof. Purely architectural details, as moldings, are deficient, and generally replaced by surface decoration and mosaics. For Oriental love of splendor and varied richness of color are more marked than artistic taste in choice and treatment of moldings. Classical forms, scroll, anthemion, acanthus, were admitted slowly among the elements of early Christian decoration. This after a systematic exclusion for nearly five centuries, when prejudices were once overcome.

3.—In Relation to Later Styles.—Byzantine had reached its height and was dying, while Western art was in its inception, and soon to pass from debased Roman—Romanesque—into the beautiful and living Gothic.

Romanesque is a general term to distinguish the round-arch style from the pointed. In this sense the Byzantine is a variety of the Romanesque. But in the early centuries there is an ornamental distinction, the more strictly Romanesque, or Latin, is simply debased Roman; the Byzantine, or Greek, is this art combined with early Christian symbolism, comprising a peculiar symbolic version of the old Roman acanthus. In its wider meaning, however, Romanesque is applied to the early Christian round-arch developments in contradistinction to the Gothic or later pointed-arch varieties of the North.

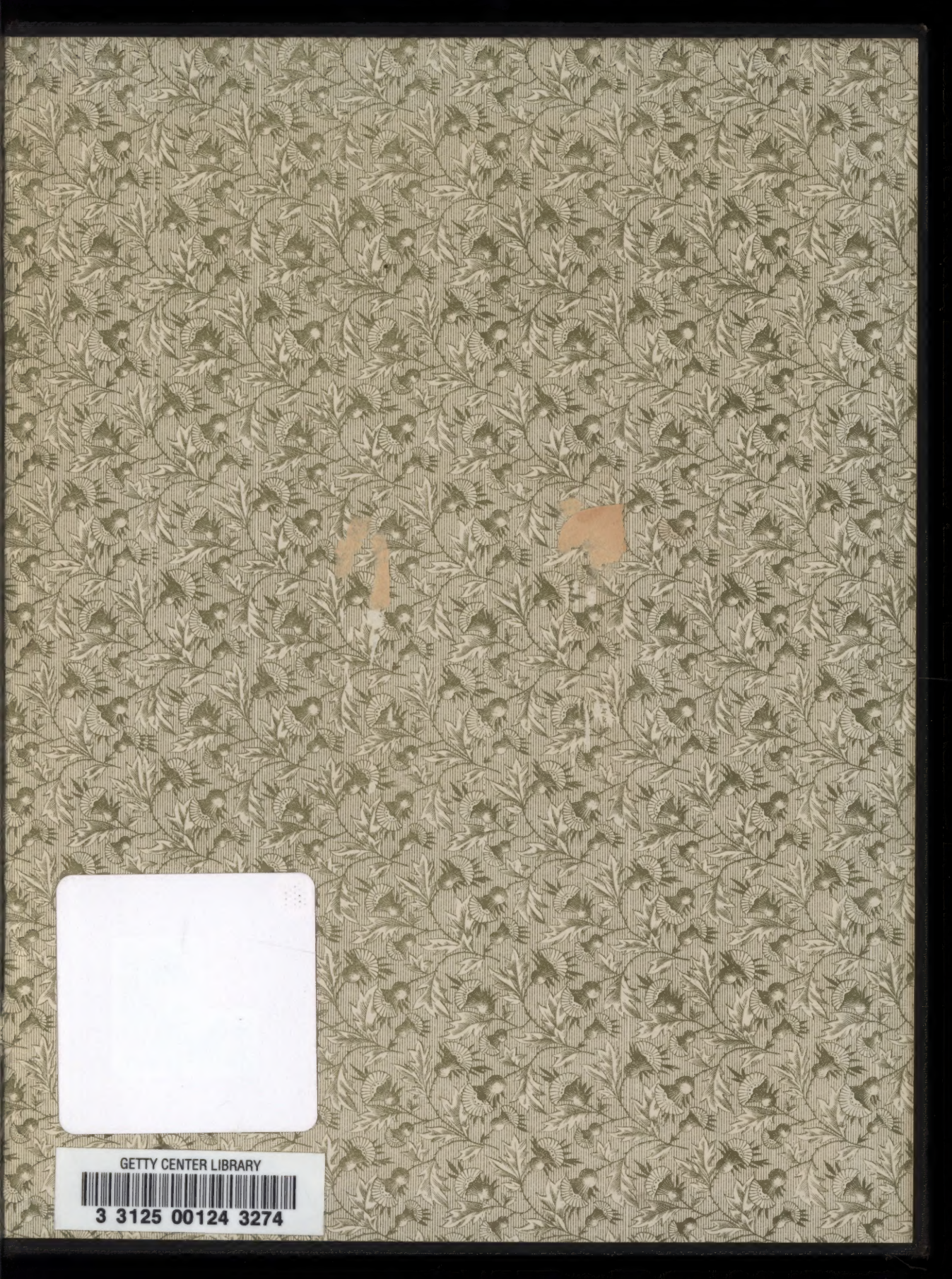
Saracenic, or Arabian art, shows strong infusion of Byzantine, whose artists were pressed into service and ordered by the Arabian caliphs and generals to raise rich mosques and palaces. By the seventh century, when Saracenic works began, the Byzantine Greeks were sufficiently skillful to make light of Mohammedan restriction respecting imitation of natural forms. Their ingenuity worked out a more beautiful and simply ornamental style than perhaps any preceding. There was no division of the artistic mind between symbolic meaning and æsthetic effect. Though Christian symbolism was excluded, yet the mere conventional ornament, forms borrowed from classic periods, and geometrical arrangement, gave a wide field for the peculiar Saracenic interlacings, arabesques and inscriptions in designs.

Gothic grew out of the Byzantine, and developed along the Rhine, in north of France and in England. Byzantine symbolism is continued in the Gothic; but the Latin-cross plan, pointed arch and spire take the place of Greek-cross plan, round arch and dome. While Byzantine ornaments are purely conventional, Gothic uses not only these traditional forms, but elaborate imitations of plants and flowers growing in neighborhood of the work, and typical geometric tracery. Gothic is (geometrical, or) geometrical only in its construction, or form, not in its spirit or motive.

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